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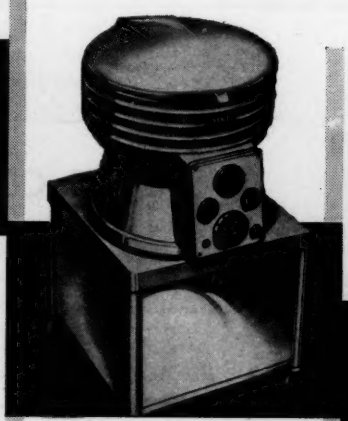

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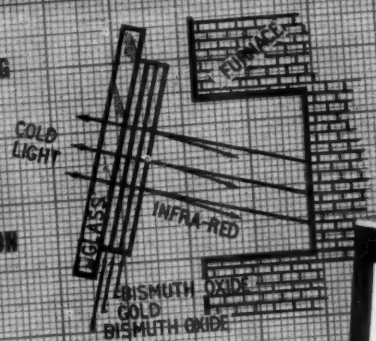

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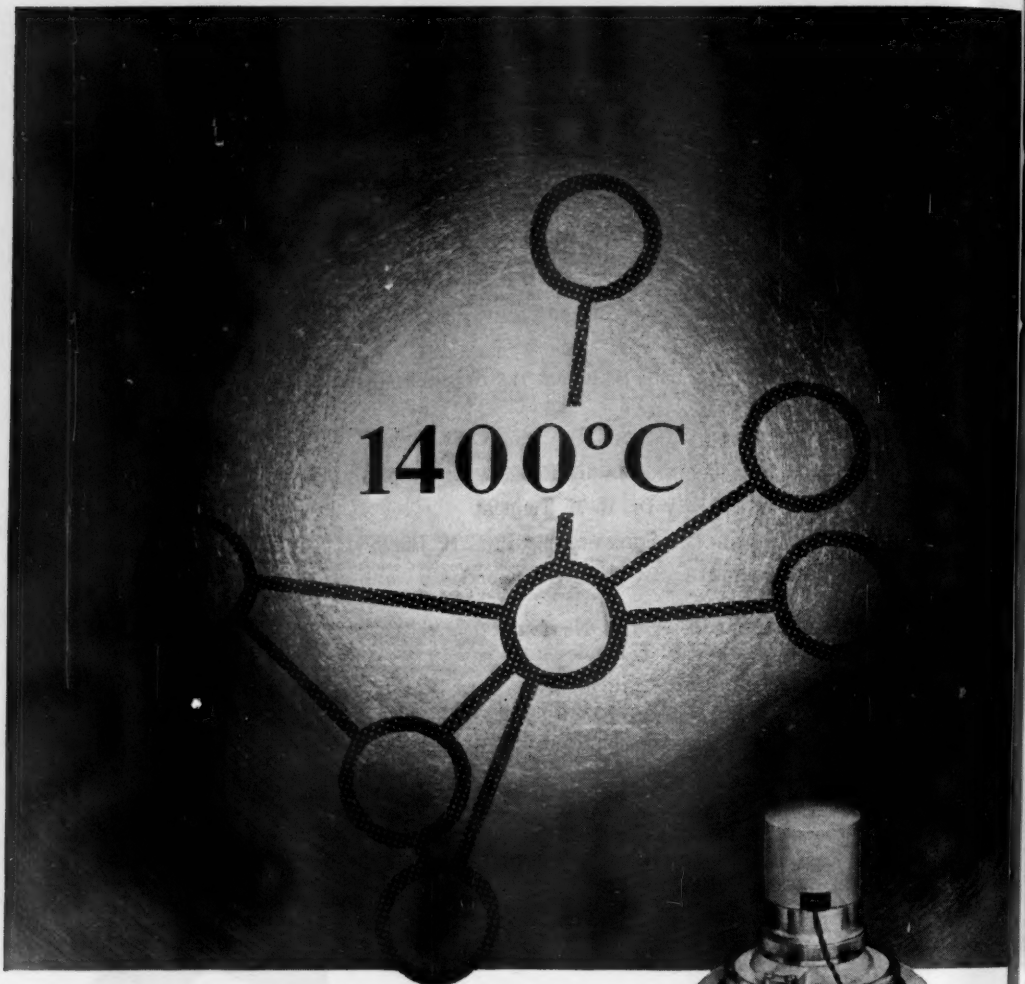

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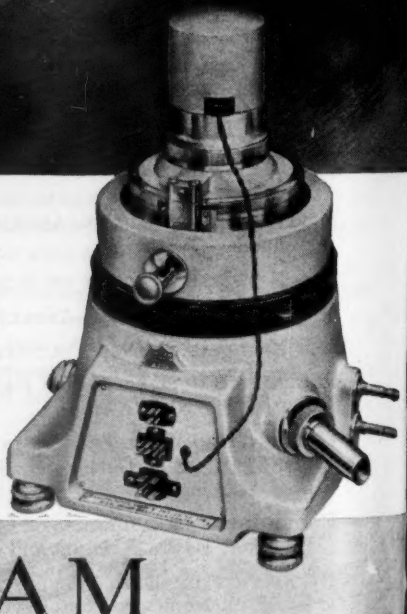

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ACADEMIC FREEDOM AND THE UNIVERSITIES OF SOUTH AFRICA

IT was taken for granted by the working party on higher education in East Africa, which recently formulated recommendations for the re-organization and extension of the Royal Technical College of East Africa, that it—as well as Makerere College and the University of East Africa, to be created eventually—would be multi-racial institutions as an indispensable element of their fully liberal nature and outlook. The University College of Rhodesia and Nyasaland has already been established as an inter-racial institution; although the two groups of students there live in different hostels, they mix without distinction in their academic work, in sport, and socially. This separation has indeed been challenged in Parliament in Great Britain, but the challenge brought not merely the desired reassurance but also evidence of a clear understanding of the nature of a university and deep respect for its autonomy.

These are vital factors if a young university institution is to establish conditions which will attract both Europeans and Africans, and enable them so to work together that the several races may make their full contribution to the development and welfare of the community. Already it is apparent that neither in Africa nor elsewhere is nationalism—or racialism—enough, and that if mankind is to gain control over events there must be the fullest possible contact of trained minds. The responsibilities which rest upon these young university institutions—and indirectly on the universities in Great Britain which have accepted special sponsoring relationships—are indeed heavy, and would tax all the experience of a mature university, with long and high traditions and an accepted place and wide influence in the community.

Even without the acute and inter-related problems of an adequate flow of students of high standard, sufficient well-trained teachers, facilities and opportunities for research, and appropriate relations with the community, including the support which professional associations are often able to give in Britain, it would not be easy for the university institutions which have developed overseas during the past fifteen years to meet the demands made on them for leadership. How much depends on the quality of leadership in the territories now achieving or verging on independence can scarcely be over-emphasized. But it is also true that the quality of the leaders forthcoming from the Colonial and overseas universities depends just as much as it does in Britain and the Dominions on the maintenance of the tradition of university autonomy, on the power of the universities to decide for themselves what students they shall admit, to select their own staff, to choose their fields of inquiry and to serve the community in such ways that their own experience and judgment indicate as best consonant with the work—in short on the tradition and ideals and the resources of a university.

The vital importance to-day of the contribution which the universities can make to leadership in society brings this question of academic freedom into the forefront. A university can only make its proper contribution to national life when it is assured of freedom to teach, to investigate, to discuss and to criticize. Deprived of any one of these, the quality of its intellectual life will decline, creative work may be stifled, research discouraged or discontinued, and ultimately the quality of its teaching sink to that of the school class-room. Amid the almost universal call for more scientists and technologists, for men and women capable of exercising responsibility and leadership in all walks of life, for handling with wisdom and vision the complex technical and human issues in an age of rapid technological change, and the unceasing discussion of how best such men and women can be found and trained, there is sometimes danger of the fundamental conditions which determine the quality of their training being overlooked.

Although there is impressive evidence from the past generation of the damage which is done to a country's real interests and to the character of its leadership by failure to respect the autonomy of its universities, the lesson does not appear as yet to have been fully learnt everywhere. That is a main reason why the whole academic world has followed with profound interest and concern the passage of the Separate University Education Bill, which on April 30 had its third reading in the South African House of Assembly. The Bill, which has been strenuously contested throughout by all the Opposition groups, has now only to go through the Senate before becoming law.

It is sufficient here to point out that the Bill provides for the creation of a series of colleges of higher education for the different Bantu peoples in South Africa, and separately for the Cape coloured people and Indians, but also prohibits the entry of non-white students to the present multi-racial universities of Cape Town and the Witwatersrand; it also removes from the University of Natal the powers it at present explicitly possesses of determining in what place a student is to receive instruction. The background was reviewed in *Nature* early in 1957 (179, 745; 1957), but since then the Committee on Science and Freedom has devoted two successive issues of its *Bulletin* to this question, the second of which (February 1958) reported very fully the impressive meeting on *apartheid* and the world's universities held in London in November 1957 (cf. *Nature*, 180, 1163; 1957). The Council of the University of the Witwatersrand also published papers relating to an

interview regarding the Bill with the Minister of Education, Arts and Science in April 1957*.

These papers are still worthy of note for the dignity with which the Council of the University of the Witwatersrand affirms its opposition in principle to legislative enforcement of academic segregation on racial grounds, and deplores the interference of the Bill with the autonomy of the independent university institutions. Noting with deep regret the failure of the Government to consult any of the university institutions concerned in these matters, the Council affirms its conviction that although the university colleges for non-whites as proposed in the Bill may be able to provide instruction for the purposes of the examinations of the University of South Africa, these institutions cannot provide the equivalent of the university education which is available to non-whites at the open universities, and that the establishment of these institutions does not justify the Government in prohibiting the University of the Witwatersrand from continuing to accept non-white students. The provisions of the Bill are accordingly regarded as not merely repugnant to the tradition of universities, but also as specially repugnant to the South African university tradition, which does not admit the idea that the whole of a university staff should be subject to appointment by a Minister and that they should be controlled in all their university activities by Ministerial regulations and by a statutory code of discipline which stifles the academic conscience.

The meeting in London in November 1957 left no possible doubt as to the strong support which is forthcoming among the universities of the world for the South African universities in their protests against the Bill, or the extent to which their belief that the Bill will be grievously injurious to university education in South Africa; and their alarm as to the implications of the Bill are shared. In commenting on that meeting, however, *Science and Freedom* points out that, while Prof. L. J. du Plessis, of Potchefstroom University, gave convincing proof by his personal views and bearing that there are people in the Afrikaans-speaking universities of South Africa who sincerely believe that the development of the natives will best be fostered in their own segregated communities and in universities specially established to serve them on a tribal basis, he failed completely to convince the meeting that the Government of South Africa is equally sincere in this purpose, and that it is not primarily concerned to perpetuate the supremacy of the white race in South Africa. Concern as to possible effects if non-whites, by entering the universities and other cultural centres, should become competent to enter leading positions in the State continually frustrates positive elements in the Government policy; and there appears to be no room for consideration of the nature of a university and how it exerts its influence in society.

* University of the Witwatersrand, Johannesburg. Papers relating to the interview between the University Council's Deputation and the Hon. the Minister of Education, Arts and Science on 1st April, 1957, on the matter of the Separate University Education Bill. Pp. 1+12. (Johannesburg: University of the Witwatersrand, 1957.)

The openly expressed view of the Council of the University of the Witwatersrand that unless the Bill is withdrawn no independent university can in the future feel secure from Government interference with its academic freedom is further supported by the correspondence quoted in the papers referred to earlier. They record an attempt by the Minister of Education, Arts and Science to misrepresent in Parliament the University's attitude, which of itself would arouse grave suspicion as to the honesty of the Government's purpose. So far from attempting to explain to Parliament the nature of the university tradition and the dependence of the vitality of a university upon the freedom of teaching, of investigation, of discussion, and of administration that have long been accorded to such institutions in the civilized world, the Minister distorted what was said by the Chancellor of the University, and when challenged tried to gloss over the matter as of no significance. Nowhere in the long reply printed in these papers does the Minister show the slightest understanding of the argument put forward by the University, or of the extent to which its views as to the nature of a university and the conditions for its effective work are shared throughout the universities of the Commonwealth and the free world.

Nor are the authorities in universities of South Africa alone in protesting against the Bill. The National Union of South African Students has been no less active, and is convinced that the issues under test in South Africa are of more than local significance. It believes that the immunity of a university from State direction is one of the most necessary and valuable of our common heritages, the worth of which has been attested in many countries and many ages, and that the State should exercise its power to guarantee this right to a university and the right of all students to choose where they will be educated, not abuse it by enforcing conformity to its political doctrines.

An 'open letter' on the threat to the South African universities sent out by the National Union of South African Students in June 1958 explained clearly the doctrine of *apartheid* and the three measures (the other two are the Fort Hare University College Transfer Bill and the Durban Medical School Transfer Bill) which are designed to force this policy on the universities. The implications of these measures for academic freedom are indicated, and the letter points out that, although the Commission appointed at the last session of the South African Parliament to consider the details of the Separate University Education Bill was prevented from discussing the principle of the Bill, the evidence heard was almost unanimous in its condemnation of the main sections of the Bill. The letter admits, however, that it is unlikely that the Commission will make any recommendation which has not received the prior approval of the Cabinet; it was sent out in the hope of arousing interest, particularly from university men and women, but also from all who cherish the integrity of learning and the aspiration of youth to develop its talents freely and creatively.

Another message, from the International Committee on Science and Freedom, was published in the *Cape Times* and the *Cape Argus* on January 29, 1959. This Committee, which represents members of 296 universities in 52 countries, condemns in this statement the policy as striking at the roots of genuine university education and menacing the standing of South African universities as members of the world community of learning, and calls on the South African Government to take heed of the disastrous consequences of its policy and to abstain from its further pursuit. Both statements direct attention to the way in which the Government sees fit to ignore informed and responsible criticism, and the ill consequences to South Africa which may well follow if it comes to be regarded as a country which does not recognize the university autonomy common to the rest of the free world.

These newspaper comments show that the Government of South Africa, despite its denial of the opportunity of consultation to the universities, its refusal to meet and examine argument and the very dubious measures to which the Minister has stooped, has not been able to conceal the extent of the opposition to the Bill and the misgivings with which it is regarded. So late as April 16, a protest meeting was held in the Great Hall of the University of the Witwatersrand in Johannesburg, in which the principle at stake was once again emphatically affirmed: "We affirm in the name of the University of Witwatersrand that it is our duty to uphold the principle that a university is a place where men and women without regard to race and colour are welcome to join in the acquisition and advancement of knowledge and continue faithfully to defend this ideal against all who have sought by legislative enactment to curtail the autonomy of the university".

The meeting did not, however, limit itself to the reaffirmation of a principle: "Now therefore we dedicate ourselves to the maintenance of this ideal and to the restoration of the autonomy of our university". The affirmation is one required continually of every member of a university, be he a member of the academic or administrative staff, or student, and the service of the ideal of the free university calls for a like dedication. To the extent that it is publicly made in the universities of the Commonwealth, the members of the universities of South Africa should be encouraged, if not more tangibly supported, as they seek to fulfil their own hard task of restoring the autonomy of their universities. The goodwill in their task which is extended to them by their colleagues in the universities of the world will be reinforced by that of men and women everywhere who recognize that societies need centres of independent thought and criticism for survival, and the dependence of that function upon the guarantee of freedom and the free university. The future of mankind is so bound up with what is happening in Africa that it must still be hoped that the South African Government will reconsider its university policy, which must inevitably destroy its own powers of exercising the wise and humane and inspired leadership that is needed throughout Africa to-day.

EVOLUTION OF GENETIC SYSTEMS

Evolution of Genetic Systems

By Prof. C. D. Darlington. Second edition, revised and enlarged. Pp. x + 265. (Edinburgh and London: Oliver and Boyd, Ltd., 1958.) 21*s*. net.

MORE than a quarter of a century has passed since, as a young man, C. D. Darlington summarized and synthesized the then recent advances in (nuclear) cytology. The last chapter in this early book (1932) was entitled "The Evolution of Genetic Systems". It dealt with the origin of chromosomes and mitosis, the sexual cycle and meiosis, the spindle mechanisms, the cytology of differentiation, the stabilization of hybridity in apomixis, complex heterozygotes, and polyploids. Seven years later the chapter had grown into a small volume, published separately, in which the author "attempted to show genetics as the study of systems of heredity and variation which rest on the basis of the chromosomes and are related to one another by processes of natural selection". This book belonged to that famous group of evolutionary treatises by Fisher, Haldane, and Dobzhansky which integrated twentieth-century genetics with nineteenth-century evolutionary thought. It assigned to chromosomal cytology, as studied at the level of the light microscope, its place in evolution. This was a brilliant contribution of fundamental significance.

Once more twenty years have passed, and Prof. Darlington offers us a second edition of his work. He feels that genetics, while grown beyond many expectations, "does not seem to have grown beyond the framework I tried to give it". Many of the chapters of the new edition, therefore, are largely unchanged from their original form, although some additions and deletions everywhere show that this is more than a reprint. But there are also new chapters. One, on "The Management of the Cell", introduces all too briefly cytological aspects of development and differentiation such as the chemical hierarchy of deoxyribonucleic acid, ribonucleic acid and protein, and interrelations between nucleus and cytoplasm. Two other new chapters, near the end of the book, are entitled "Types of Plasmagene", and "Heredity and Infection". They "admit a third begetter" of genetics, Pasteur, "whose ideas on microbes and molecules", with those of Darwin and Mendel, "are becoming clearly imprinted on our diagram of nature". In these sections, Darlington discusses our knowledge of extra-nuclear transmission in *Drosophila*, *Culex*, witches' brooms, rogues in peas and tomatoes, and in other cases, and tries to unify it with modern insights into viruses, microbial genetics, and cancer. In a final new chapter on "Initiative in Evolution", the author compares what he calls "the general opinion of Darwinian geneticists" with his own conclusion from the analysis of the evolution of genetic systems. To the others he ascribes the view that natural selection can only produce results which are of immediate utility to the species, while he himself stresses the principle of pre-adaptation in which species acquire an infinite variety of mechanisms which are of no immediate use to them but prepare them for unexpected events. "An automatic property of foresight" is the ingenious label which he applies to this concept.

It cannot be expected that a revision of a book which had an important impact in the 'thirties will do

the same in the 'fifties. The earliest insights have long become part of our thinking, either as possessions or as starting points for different views. The newer opinions on plasmagenes, infection, and differentiation seem less unique and more ephemeral. In details, one wonders why a wool-thread model of crossing over is still discussed and only a mention of molecular models of deoxyribonucleic acid and their relation to crossing over, why chromosomes are unreservedly called "molecules of immense size", why there is nowhere a treatment of the recent work on nuclear transplantation and differentiation, why the special X-chromosome–autosome balance in *Drosophila* is made to appear as a general scheme of sex determination, why "the virus" is called "a protein molecule", and why the references to the literature include so many minor items when some of the major ones are omitted. But we should not demand painstaking accuracy and coverage from an author whose merit has been to give us stimulating, if subjective, treatments of the place of cytology in genetics and evolution.

CURT STERN

NEW LIGHT ON OLD DARKNESS

Listening in the Dark

The Acoustic Orientation of Bats and Men. By Prof. Donald R. Griffin. Pp. xviii+413+16 plates. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1958.) 60*s*. net.

IN 1946, when zoologists everywhere were disentangling themselves from war-service jobs and trying to catch up with six years of unread literature, the most exciting discovery was Galambos and Griffin (1941) on "Obstacle Avoidance by Flying Bats". This short paper, though it raised more questions than it answered, carried instant conviction. Here evidently was the solution in principle of a problem which had rankled for 150 years. It only remained to determine in detail how the echo-location system of bats worked with the necessary sensitivity and precision.

This enchanting and enthralling book tells of the events leading to that epoch-making paper in 1941, and of the subsequent eighteen-year effort to answer the questions which it raised. But it tells much more. Dr. Griffin is no narrow specialist. He is that rare combination, a first-class experimenter who is also a first-class naturalist. A lesson implicit throughout the book—and a lesson that zoologists disregard at their peril—is of the degree to which the successful solution of a problem is dependent on the correlation of laboratory experiment with close and well-directed observation in the field.

The book opens with two chapters on the general biology of bats, including sections on their economic and medical importance and on migration and homing. Then there is an account of the genesis of the echo-location problem from Spallanzani's first observation in 1793 that bats, unlike owls, could avoid obstacles in complete darkness and Jurine's demonstration in the following year that this capacity was lost if their ears were blocked, to the suggestion of Hartridge in 1923 that bats emit high-frequency sound which generates a detectable echo.

There follow chapters on the voices of bats and on their hearing, on critical tests of their ability to avoid obstacles, and on the evidence of their catching insects by echo-location. So far the account is based principally on the Vespertilionidæ, which Dr. Griffin has known best and longest. Chapters 8 and 9 deal with echo-location in the long-eared bats, the horseshoes, the fish-eating bats, the fruit bats and the vampires.

The remaining chapters carry the implications of echo-location beyond the Cheiroptera. There is an account of Dr. Griffin's own demonstration of echo-location by *Steatornis*, the oil-bird of Caripe, and of Schevill's evidence for echo-location by whales. There are instructive comparisons with the navigational devices of electric fish described by Lissmann and with the British inventions of Asdic and R.D.F. (now called sonar and radar respectively in deference partly to American susceptibilities and partly perhaps to euphony). There is a chapter with implications of serious practical importance on echo-location by the blind. Finally, Chapter 15, entitled "The Experimental Naturalist in Modern Science", is a persuasive and beautifully written plea for the preservation of an open mind, a plea which every zoologist should read with self-critical attention.

Although Dr. Griffin freely acknowledges the assistance he has received from physicists, it is clear that he has on occasion been hampered by their *obiter dicta* about what is possible and what is not, as Darwin was hampered by Kelvin's confident and erroneous assertions about the age of the Earth and the time available for evolution. *A propos* the possibility that *Noctilio* echo-locates fish just below a water surface (p. 244), "one physicist has told me that if I should persist in even considering it seriously he would cease to believe anything I ever have to say about bats and their acoustic orientation!" Dr. Griffin was more moved than he need have been by this horrific threat, which must have been based on prejudice and a failure to consider the conditions. A fish possessed of an air-bladder and situated half a wave-length below the surface will 'look like' a hole in that surface to an echo-location system situated above it: and the detection of such a hole would surely not offer any special problem to animals which can find a crevice in a solid wall or avoid a wire 0·25 mm. in diameter.

The index and bibliography seem to be both adequate and accurate. The book is well produced and misprints are very few. The text is also accurate wherever I have been able to check it, though I take exception to the statement on p. 146: "Under favorable conditions experienced human subjects can estimate the angular position of a sound source with an error slightly less than 10°". Under favourable conditions even inexperienced human subjects can do a great deal better than that: and so can cats and dogs and chickens, as Englemann showed long ago.

There is one inconvenient omission. Dr. Griffin, after thirty years of intimacy with bats, has altogether too much confidence in the non-cheiropterist's ability to assimilate and retain the systematic information in the first chapter of the book. There is nowhere to be found a table of bat affinity; and many readers may feel compelled, as I did, to make for themselves one showing the orders and families of bats and the position therein of each genus mentioned in the text, and its geographical distribution. It is to be hoped that future editions will include such a table in a form which allows quick reference.

On its factual content this book is well worth its place (and its not inconsiderable price) on any reference shelf, but content does not fully explain

why, once begun, it is so difficult to put down until it is finished. Its grip is only partly due to the fact that it is written in vigorous, grammatical and intelligible English. On reflexion it seems to me that its charm lies in the candour with which Dr. Griffin recalls his expectations at every stage in his long pilgrimage, even when they led him astray, and the frankness with which he records the difficulties, practical and theoretical, administrative and financial, real and imaginary which he has encountered. Because he does not mind admitting his mistakes, one comes to realize that they have been extremely few. But the reader is carried expectantly and more or less effortlessly from crisis to crisis. The virtues of the authoritative treatise have been seamlessly welded to the virtues of the 'Whodunit', and the book can be recommended with confidence not only to the zoologist who must have it, but also to anyone at all with an I.Q. of more than 100 who can afford to buy it or who can beg, borrow or steal it.

R. J. PUMPHREY

COSMIC-RAY SHOWERS

Extensive Air Showers

By Dr. William Galbraith. Pp. xvi+211. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 40*s*.; 7.50 dollars.

DR. GALBRAITH'S book on the extensive air showers of the cosmic radiation is a welcome addition to the rather limited number of books which deal with cosmic-ray phenomena. The author, in his preface, states that it is primarily intended for physics students and graduates who wish to find out what has been done in this field of research, and it may also find a more general appeal to workers in other realms of physics. It may be said at once that the book is ideally suited for a research student embarking on a study of some aspect of the cosmic radiation or nuclear physics, but I fear it is to be doubted whether those not directly interested in this limited field will be prepared for the concentration which is needed when reading this book.

In his introduction, the author gives an excellent résumé of the crucial experiments performed since extensive air showers were discovered in 1938 and the development of the theoretical concepts associated with them. The main body of the book contains eight chapters. The first chapter is mainly theoretical and deals with the photon-electron cascade in detail and the nucleon cascade rather more briefly, with a note on the problem of fluctuations. Five further chapters contain accounts of experiments, with the necessary theory interposed, and deal with the lateral density distribution of electrons, the penetrating particles, the density spectrum, longitudinal development and variations in the rates of extensive air showers. The two remaining chapters deal with experiments performed underground and the Čerenkov light produced by air-shower particles.

The impression that is left on reading this book is that here is a subject of such inherent complexity that there has been a definite tendency to set up apparatus and record results, rather than perform planned experiments with definite objectives in view. As a result the subject abounds with experimental results many of which are difficult to analyse in a way which furthers our understanding of extensive air showers. Dr. Galbraith's book will therefore be of the greatest use to future experimenters as he is not only a keen judge of an experiment from a practical point of view but is also able to see whether it leads to a better understanding of the subject. For this reason, Chapters 2–5, which at first sight may seem to be no more than catalogues of experiments, will repay careful reading. In the chapter on the Čerenkov effect we find traces of the enthusiasm for this fascinating subject which led Dr. Galbraith to participate with such success in the early experiments in which Čerenkov light was found to be associated with extensive air showers.

I should have preferred a fuller account of the statistical nature of the arrival of shower particles with a discussion of the Poisson distribution early in the book. The notation used where the Poisson distribution is discussed on p. 98 tends to be confusing, as the symbol m is used for the number of particles crossing a detector while m is used as an abbreviation for metre and in one case the italic m occurs as an unfortunate misprint. In general, the text of the book is very well set out and misprints are rare. Many of the diagrams, however, are small and confusing and some contain information which is not referred to in the text or contain symbols which do not agree with those of the text.

R. M. TENNENT

ADVANCES IN VETERINARY SCIENCE

Advances in Veterinary Science

Vol. 4. Edited by C. A. Brandly and E. L. Jungherr. Pp. xi+414. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 12 dollars.

THIS volume is composed of ten sections each dealing with problems of practical importance to the stock owner and the veterinary surgeon.

Of these sections, the second, which brings us up to date with information on radiation injury, and the eighth, which presents the current picture of the toxicity of insecticides and herbicides to livestock, will be more avidly scrutinized. At a time when civilization itself may seem to be at the mercy of radiation, the very full information and generous bibliography afforded by this volume are of real assistance to all whose duty it may be to plan and organize civil defence schemes.

As the authors wisely observe—"the widest port of entry into human beings of fission products is through animal products, particularly milk", and the role of veterinary science in maintaining a safe food supply in the face of radiation hazards becomes increasingly obvious.

The entry into the field of agricultural and veterinary parasitology of new insecticides, including the chlorinated hydrocarbons and the organic phosphorus compounds, has posed many problems. Knowledge in this new field is necessarily limited, but the chapter on this subject, if short, is none the less valuable and well supported by its references.

Chapters on defence against imported animal diseases, X-ray therapy in veterinary medicine, genetics and disease, and the epizootiology of leptospirosis bring further knowledge to that already marshalled in current veterinary literature and serve to emphasize once again the basis of a rational approach to these subjects.

Infectious diseases of sheep occupy an important chapter in which bacterial, rickettsial, viral and

protozoal diseases of both lambs and adults receive full consideration.

Pigs have two chapters devoted to them—one on infectious atrophic rhinitis and one on enzootic virus pneumonia, and Glasser's disease. In view of the somewhat confused state of knowledge and understanding of these diseases, the clarity with which these chapters are written will be highly appreciated by all readers.

The chapter on Jöhne's disease is of paramount importance to British readers; with the anticipated eradication of bovine tuberculosis from Great Britain within the next few years, the problem of Jöhne's disease assumes new prominence. Indeed, it may well be that Jöhne's disease may be the next target of the animal health authorities in Great Britain. The problem of diagnosis of this disease is apparently far from solved, but, piece by piece, evidence on modes of infection is building a picture from a study of which must one day come a rational means of control and maybe eradication.

The contributors to this volume all deserve the highest praise for the quality of their essays; unnecessary diction is in all cases reduced to a minimum and references are unstintingly given.

If illustrations are somewhat regrettably few in number, the reader will appreciate the difficulties involved in copious illustration of the particular subjects covered. The verdict on this recent work must surely be that it appears at a time when the information it gives is urgently needed and that its readers acknowledge with gratitude the magnificent effort made by its distinguished contributors.

H. Burrow

CONTROL FUNDAMENTALS

Handbook of Automation, Computation, and Control

Edited by Eugene M. Grabbe, Simon Ramo and Dean E. Wooldridge. Vol. 1: Control Fundamentals. Pp. xx+1006. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 136*s*. net.

THIS is the first of a series of three volumes and is prepared by a staff of 29 contributors from an impressive cross-section of American universities and industrial organizations.

A handbook is expected to contain a body of material which is related by a common theme. The theme of this work is "Control Fundamentals", but this term has clearly been given a more general meaning than is currently ascribed to it in Britain. Only about half the volume is concerned directly with closed-loop control systems and their analysis and synthesis. The rest is devoted to general mathematics, numerical analysis, operations research and information theory.

The principle followed in Section *A* on general mathematics is to present the notation and major ideas and theorems of each subject chosen for treatment. For rigorous proofs the reader is referred to the generous bibliographies at the end of each chapter. The presentation is necessarily concise and applications of the various techniques described are not given. This leads to the obvious danger that the material may be regarded as insufficiently rigorous by the mathematician and insufficiently practical by the control engineer.

Three chapters in Section *A* are devoted to set theory, matrix theory, and Boolean algebra, respectively. Eight chapters are concerned with algebraic, integral, finite difference and differential equations, complex variable theory, conformal mapping, operational methods and Laplace transforms. Finally, two chapters deal with probability theory and statistics, respectively.

Section *B* on numerical analysis is likely to be of increasing interest as the use of digital computers becomes more widespread. Here are described interpolation and curve fitting methods, numerical differentiation and integration, matrix inversion, eigenvalues and eigenvectors and methods of solving differential and partial differential equations. Computer storage requirements and number of operations are given in tabular form for the various techniques.

Section *C* on operations research occupies 129 pages and is a fairly complete description of the methods used in obtaining optimum solutions to problems arising in industrial systems. It forms a useful introduction to the subject for the control engineer.

Information theory and transmission, in Section *D*, occupies 114 pages and contains a full exposition of the main concepts of information theory, prediction, data coding and the design of optimum filters. Useful curves and tables are given for the design of Butterworth–Thomson filters.

Feedback control in Section *E* occupies 427 pages. Here are presented the well-established techniques for the analysis and synthesis of control systems, with many valuable tables and curves. The first two chapters on methodology and fundamentals include tables of typical component equations and lists of analogous elements of electrical, mechanical and hydraulic form together with their transfer functions. The chapter on stability deals exhaustively with the use of the various graphical methods for stability determination. Transient and frequency response determination is described by analytical numerical and graphical methods. Design charts are given for deriving closed-loop transient and frequency responses from open-loop characteristics and a four-place table of $\sin x/x$ is provided for use with a numerical method of transient response determination. Feedback system compensation by series and feedback methods is described and tables are provided showing electrical, mechanical, hydraulic and pneumatic compensating networks and their transfer functions.

The chapter on noise deals with its mathematical description and measurement and with the response of linear systems to noisy inputs. Optimum design for stationary random inputs is treated.

In the penultimate chapter methods of non-linear system analysis are described with particular emphasis on the describing function method. Tables of describing functions are given for a large number of amplitude-dependent non-linearities. A surprising omission is the subject of noise in non-linear systems, on which much work has been published in the past few years.

Sampled data systems are rather briefly treated in the last chapter but useful tables are given of output transforms for basic sampled systems.

This handbook, in addition to presenting most of the existing techniques used by control engineers, also presents the mathematical framework on which much future development will depend. It will appeal most to research workers and development engineers in the ever-widening field of automatic control.

P. H. Hammond

Transistor Technology

Vol. 3. Edited by F. J. Biondi. (The Bell Telephone Laboratories Series.) Pp. xiii+416. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 94*s*.

DOUBTS were cast in the review of Vol. 1 and 2 of "Transistor Technology"—a review (see *Nature* of January 10, p. 72) written before the third and final volume was available—of the likelihood of the three volumes satisfactorily filling a serious gap left in the coverage of text-books and reference books. The doubts are largely dispelled by Vol. 3, however. It is only little more than half the size of either of the two earlier volumes, but it contains by far the best descriptions yet given of most of the modern techniques for making junctions and triode structures—many of them brilliantly conceived, carefully worked out and adaptable to large-scale production. It should appeal as strongly to newcomers seeking more than a superficial understanding of the techniques as to the more experienced research workers, technologists and teachers (though as yet this part of the subject is apparently little taught).

The book opens with chapters which classify the methods used to control impurity distributions and to form junctions in germanium and silicon, and show how the several ideas based on liquid-phase freezing and on diffusion in the solid can be exploited. The processes which monocrystalline semiconductors undergo in becoming diodes or transistors are next described. Some chemical processes and the making of ohmic contacts apply widely; others are more specialized, for example, jet etching, alloying and diffusion, the last two being treated in the detail warranted by their importance to-day. The last quarter of the book is on other branches of the subject. Some of the methods for measuring the rate of recombination of minority carriers, both in the bulk semiconductor and at the surface, are described; and a basis for designing equipment to measure selected parameters of transistors is analysed, in terms of ease, accuracy and value to the user. A few pages are devoted to reliability, a subject which is gaining importance.

The presentation of all three volumes conforms with the high standard of the series. It is to be hoped that we can look forward to further volumes, at intervals of a few years, keeping us up to date on material preparation and on device design, fabrication and performance.

J. R. TILLMAN

Studies in the Mathematical Theory of Inventory and Production

By Kenneth J. Arrow, Samuel Karlin and Herbert Scarf. (Stanford Mathematical Studies in the Social Sciences, No. 1.) Pp. x+340. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1958.) 70*s*. net.

THIS book consists of a series of interrelated research papers. The results have been obtained during the past three years and are now published as the first volume of the new series of Stanford Mathematical Studies in the Social Sciences. Most of the research was carried out at Stanford University, largely under the auspices of the Office of Naval Research.

The quantitative study of inventory and production is a relatively new branch of applied mathematics; hence about the first fifty pages of the book are taken up with the historical background, the nature and structure of inventory problems, and summaries of the results of succeeding chapters. It is essentia' for the reader to study this part of the book, in order to grasp the general mathematical concepts which are developed later in special contexts. Part 2 consists of four papers covering the determination of optimal policies in the case of deterministic processes. One relates to production with marginal cost increasing with time, another to production planning with no storage facilities, and a third is concerned with the smoothing of production. Part 3 relates to stochastic processes and includes several papers on various aspects of the Arrow – Harris – Marschak dynamic model, and a paper relating to a hydroelectric model. The last part of the book is concerned not with the determination of optimal policies but with the operating characteristics of given 'simple' policies, and this is realistic in cases where it is impossible or too difficult to determine the optimal policy. There is a very important and interesting chapter on the application of renewal theory, including recent results of L. Takács.

It is only fair for the reviewer to point out that the present work involves advanced mathematics in every paper, and it is not likely to be understood by either managers or operational research workers who have only taken mathematics as a subsidiary subject at a university. It is certain that results of practical significance are implicit at various points throughout the book. But a good deal of sifting and simplification are necessary before the operational research man can find a result which he can take away and use at once.

L. S. GODDARD

Looking and Finding

By Geoffrey Grigson. Pp. 120. (London: Phoenix House, Ltd., 1958.) 9*s*. 6*d*. net.

ALTHOUGH well known as a writer on poetry, art, history and archæology, this is Geoffrey Grigson's first book for young people. The subtitle describes it as a help to "looking and finding and collecting and reading and investigating and much else". This breathless approach is continued throughout the whole of the not extensive text in which young people are advised how to start with maps and charts; how to use books and read them in "skipping and picking and jumping"; how to make discoveries about the houses they live in and what this has to do with inscriptions and phoenixes and salamanders; about yew trees and green men in churchyards; how boys and girls can make maps of their own manors with the fields, mills and ponds, and how to find, in the country, pack-bridges, toll-houses, tithe barns, wells, springs, withy beds, canals and locks, lime-kilns and many footpaths. In addition, young people are advised where to make archæological and palæontological discoveries and how to make use of museums. For those who wish there are also hints about how to make and manage their own art galleries.

Mr. Grigson's object in writing a book of this sort is wholly admirable, and parts of it will appeal considerably to some extraordinary children with somewhat unusual parents. The majority will find its pace too rapid, its frequent change of direction too violent, and its repeated exhortation to go and do something not so inviting as those sections where the author takes time off to show them what they should look for.

T. H. HAWKINS

MICROSEISMIC RESEARCH AT THE NATIONAL INSTITUTE OF OCEANOGRAPHY

By Dr. H. M. IYER and B. J. HINDE

GREAT BRITAIN is a good place for detailed research on microseisms, because the large number of storms with varying speeds and intensity that form in the Atlantic Ocean each year are usually well charted, and wave information is also available. Three important contributions which appear more or less as milestones in the history of the subject have been made from the British side. These are: (*a*) the wave-interference theory of microseism generation[1]; (*b*) the correlation technique for the estimation of composition and direction of propagation of microseisms[2]; (*c*) the design of the electronic-feedback seismograph[3].

Iyer[4], working on seismograph records from Kew Observatory, made a detailed analysis of microseisms associated with a number of Atlantic storms. The direction of approach of the waves at the recording station was estimated using a modified form of Darbyshire's correlation technique. The following were some of the results.

In general, there exists a composite microseismic source in the wake of a moving storm. The microseisms consist of a mixture of Rayleigh and Love waves. The Rayleigh waves form the main part of the information and the Love waves resemble background noise. The ratio of Rayleigh to Love waves resembles the usually accepted signal-to-noise ratio in any similar phenomenon, and appears to be a function of the distance of the generating source. Thus the farther microseisms travel, the smaller this ratio.

In the winter of 1957–58 nearly twenty major 'microseismic storms' were recorded by an experimental east–west component seismograph at the National Institute of Oceanography. Nothing more than visual reading of the records was possible from these single-component data, and the aim has been to have a three-component microseismic station equipped with a rapid data-handling system.

The new microseismic station has now been installed at the National Institute of Oceanography, Wormley, Surrey. It has two sections, the seismographs and the automatic analyser.

The electronic feedback seismographs developed by Tucker[3] are used at the station. The seismograph has a very high magnification (up to 18,000) and a flat response from 1 to 10 seconds period, a combination of characteristics rarely obtained, though essential for microseismic research. The instrument is mechanically robust and easy to calibrate. In the properly engineered model both east–west and north–south components are incorporated in the same instrument, thus reducing the overall size of the station. The aim is to have a self-levelling system for the seismograph so that it can be buried in a borehole, thus eliminating the need for elaborate and costly seismograph vaults. A vertical-component seismograph employing the same principle has also been designed and is in operation. The instruments

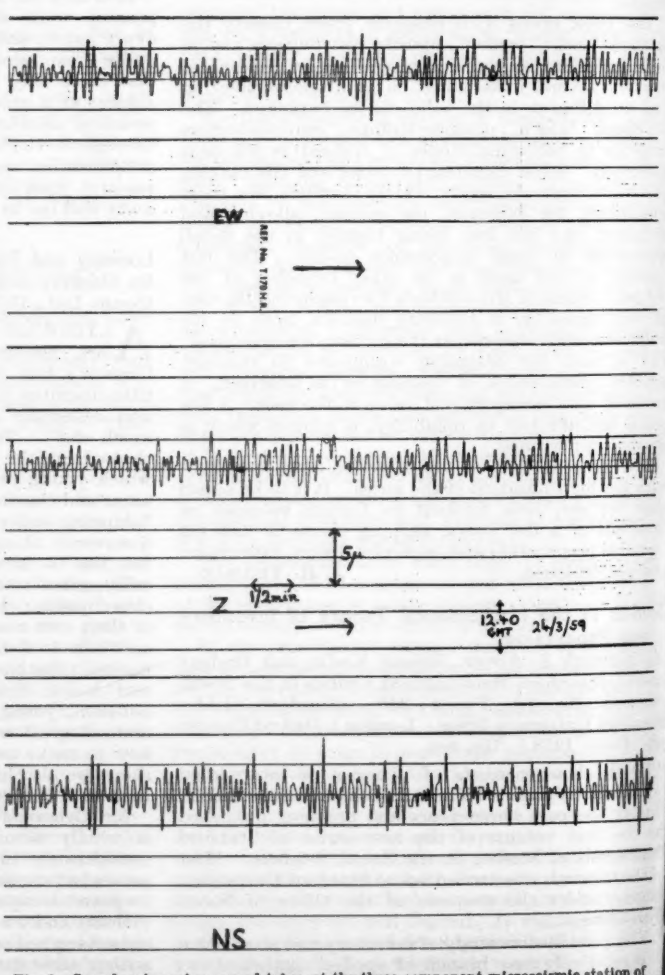

Fig. 1. Sample microseism record taken at the three-component microseismic station of the National Institute of Oceanography

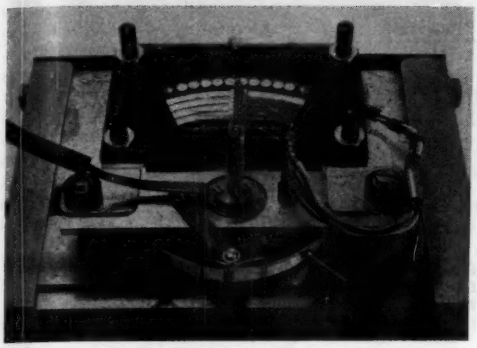

Fig. 2. The contact galvanometer used for directly analysing microseisms from seismographs

are at present accommodated in a brick-lined pit in the lawn, and the proximity of buildings, trees and the railway does not have any spurious effects. The electronics associated with the seismographs and the recorders are kept in the main building and are connected to the pit by cables. Fig. 1 shows a sample record taken on the three-channel recorder.

The information needed from the seismograph signals is root mean square amplitude, period, and the correlation coefficients between the components (for computing composition and direction of propagation). These computations must be made as the information comes through from the seismographs without any appreciable time delay.

The output from each seismograph is fed to a robust moving-coil meter provided with a system of platinized contacts (Fig. 2). The 'dot' or circular contacts are used for measuring root mean square amplitude and the 'strip' contacts for period and correlation measurements.

It is not proposed to explain here the detailed operation of the analyser. It will only be mentioned that the correlation coefficients are calculated by using the meters in two different channels to indicate automatically at regular intervals of time whether the arms are deflected in the same direction or opposite directions. This method has been used with great success by Akamatu[5] and Aki[6] in Japan for the study of short-period microseisms, in conjunction with an electronic computer for the analysis.

Fig. 3 shows schematically the final layout of the microseismic station. The filters can be set to study microseisms of different periods, and this as well as the complete sampling programme is controlled by the time-control circuit. The phase-shift network is used to correct for the phase difference between the horizontal and vertical components of Rayleigh waves in microseisms. For storage of information an automatic camera photographs the counters at the beginning and end of each operation.

Apart from the interest in microseismic study, such a seismic station should be of considerable interest to earthquake seismologists. A three-channel recorder has been provided for continuous recording for the benefit of those interested. The high magnification in the 1 to 10-second region should be of particular interest in earthquake studies.

Fig. 4 shows a sample record of an earthquake (epicentre 71° N., 8° E.) taken on the new seismographs (the three channels were recorded independently and put together). A very interesting pattern of long waves (75 seconds period) was recorded by the experimental east–west component seismograph on

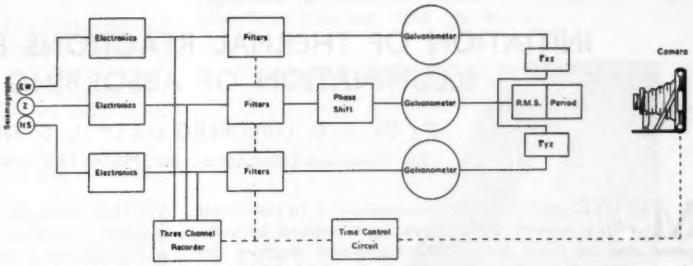

Fig. 3. Schematic diagram of a proposed microseismograph station

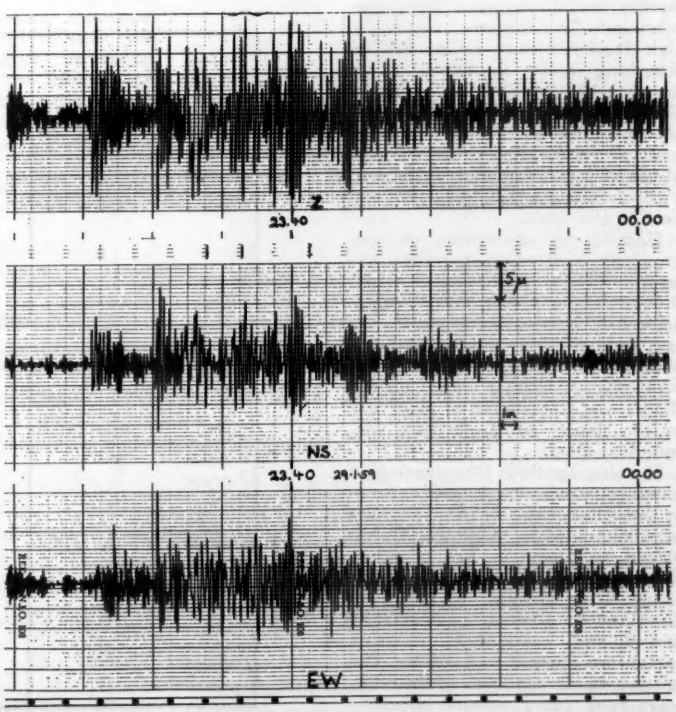

Fig. 4. A sample earthquake record (epicentre 71° N., 8° E.)

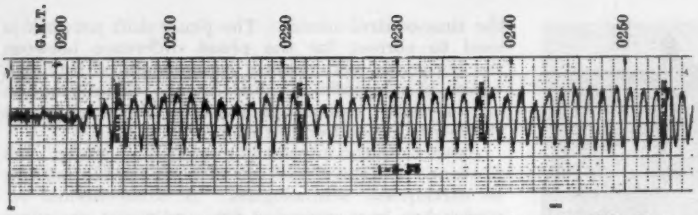

Fig. 5. A peculiar long-period record obtained on the east–west experimental seismograph between 0200 h. and 0250 h. G.M.T. on November 1, 1958

November 1, 1958 (Fig. 5). This could not be attributed to any earthquakes listed in the U.S.C.G.S. epicentre cards.

The system described might form the basis of a simplified storm-warning system in areas where such warnings are still needed. Vast expanses of the Pacific and Indian Oceans are inadequately covered meteorologically, and microseismic stations would be of great value in such areas. It is too early to predict the full utility of the new microseismic station from this point of view, but at least it can be said that it is a simple system with a sound theoretical and practical basis.

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[2] Darbyshire, J., *Proc. Roy. Soc.*, A, **202**, 439 (1954).
[3] Tucker, M. J., *J. Sci. Instr.*, **35**, 167 (1958).
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[5] Akamatu, K., *J. Phys. Earth*, **4**, 81 (1956).
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INITIATION OF THERMAL REACTIONS BY THE FLASH ILLUMINATION OF ABSORBING BODIES

By Dr. J. L. LUNDBERG and Dr. L. S. NELSON
Bell Telephone Laboratories, Inc., Murray Hill, New Jersey

MINUTE particles, filaments and foils of materials which absorb light have been heated to temperatures as high as several thousand degrees by absorption of a single intense flash of visible light. Heating by flash illumination may be used as a general technique for initiating thermal reactions rapidly, and in comparatively large volumes. The requirements are a high luminous flux falling on an absorbing body immersed in a transparent insulating medium. Using a variety of matrices and absorbers, many thermal processes, such as explosions, pyrolyses and phase changes, have been initiated within the few milliseconds of duration of the flash.

Heating by absorption of continuously emitted visible light has been used for many years[1]. Although Eggert[2] has used intense flashes of light to ignite explosives and oxidize thin aluminium foils, little has been reported on the dependence of thermal effects on the shapes and dimensions of absorbers or the nature of the matrix surrounding them.

Heating by flash illumination of heterogeneous systems first occurred in these Laboratories when samples of commercial polymers were placed, as shown in Fig. 1, along the axis of a spiral quartz discharge lamp (similar to lamp III described by Christie and Porter[3]) and flashed, using 5,000 J. from capacitors charged to 4,000 V. The heterogeneous pyrolysis of the polymers took place around normally occurring particulate impurities, yielding gases, carbon and fluorescent products[4]. Fig. 2 shows polyethylene sheet which had been placed in a borosilicate glass tube and degraded by exposure to one flash. The degradation is essentially independent of the chemical nature of the polymer, since polytetrafluoroethylene, regenerated cellulose, nylon,

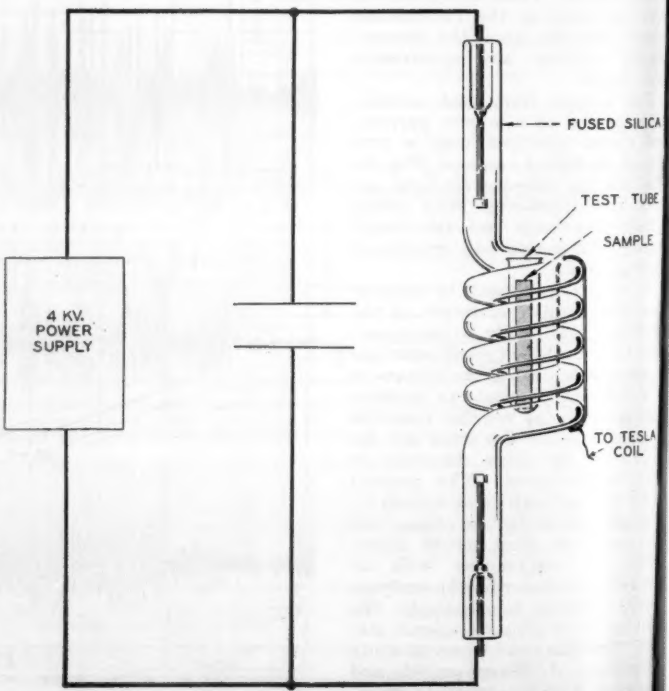

Fig. 1. Experimental arrangement for heterogeneous flash heating

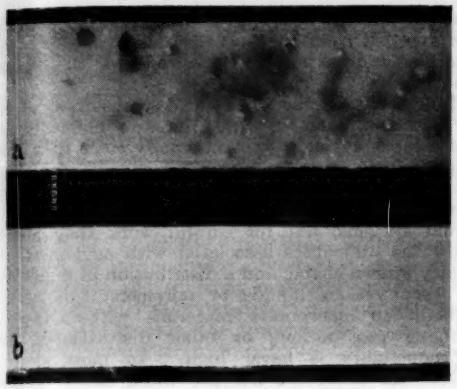

Fig. 2. (*a*) Polyethylene degraded by one flash of 5,000 joules at 4,000 V. (*b*) Control sample

polyethylene, polystyrene and poly*iso*butylene all behave similarly, unless carefully prepared without trapped particulate matter. Clean polymers do not show this type of decomposition in the flash, but can be degraded if absorbing bodies are suspended in them.

If an isolated absorber of small dimensions is irradiated in a transparent matrix, the rise in surface temperature can be estimated from simple heat-balance equations[5]. Fig. 3 shows temperature rises estimated in this way for graphite spheres, cylinders and plates of various radii or thicknesses suspended *in vacuo* or in a liquid hydrocarbon and flashed at half our maximum energy (648 μF., 4 kV., 2·5 msec.). As the radius r of the heated body decreases from large values (1,000μ) the temperature increases, because gradually less energy is used to heat the absorbing body by inward conduction. *In vacuo*, where no outward conduction into the matrix can occur, the surface temperature continues to increase as r decreases until the limit of black-body re-radiation of the incident energy is reached—for these flash conditions at about 4,100° C. for bodies of radius less than 1μ. The validity of this estimate was demonstrated by vaporizing *in vacuo* tungsten

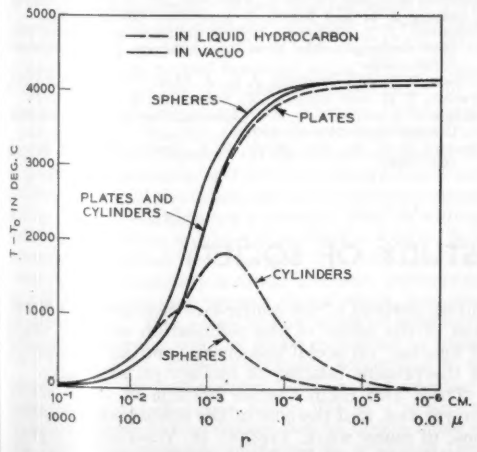

Fig. 3. Rises in temperature estimated for graphite-like absorbing bodies of various sizes exposed to flashes of 2·5 msec., 5,000 joules, 4,000 V.

and molybdenum as well as carbon of these dimensions almost explosively in a single flash.

When spherical or cylindrical absorbers are placed in a condensed transparent matrix such as a liquid or polymeric hydrocarbon, conduction of heat away from the absorbing surface occurs, and the surface temperatures decrease after going through maxima near 10μ. Thus, carbon particles of large diameter (1,000μ) and also carbon black of very small particle size (very much less than 1μ) do not initiate degradation in polyethylene, whereas particles in the size-range 1–100μ cause severe decomposition of the type shown in Fig. 2.

Absorbing foils or platelets, however, should achieve essentially similar surface temperatures in the flash, whether *in vacuo* or in a condensed medium, because heat conduction outward from a foil is not a function of thickness, compared with the strong dependence on radius in the case of spheres or cylinders. Thus, the highest maximum temperatures in condensed matrices should occur with absorbing foils less than 10μ thick.

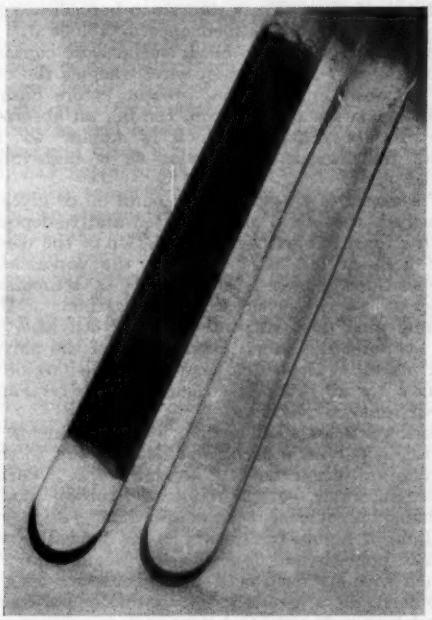

Fig. 4. Mineral oil flashed once at 10,000 joules at 4,000 V. Opaque sample contained 25 metres of 7·5-micron tungsten wire before flashing. Clear sample had no heterogeneous absorber

Because of experimental difficulties, we have never measured temperatures directly, but our experiments seem to be quite well explained by these estimates.

Higher maximum temperatures can probably be obtained by increasing the light intensity either by increasing the energy input to the lamp, or better, by decreasing the duration of the flash. Certainly, the temperature-range of ordinary chemical interest (up to 10,000° C.) seems readily achievable in heating times of 100 microsec. or less by flash heating with relatively modest energy inputs (of the order of 10^4 J.).

Heating by flash illumination has been used[6] to evaporate *in vacuo* powdered silver, carbon, chromium, molybdenum, nickel, tungsten and zinc of particle

diameters less than 100μ. When flashed at fairly low intensities, metal foils 5–10μ thick were etched, revealing microstructure of the metal. At higher intensities the foil melted into a small droplet, and at still higher intensities vaporized[4]. Powdered coal has been vaporized and pyrolysed by flashing *in vacuo* and in hydrogen and halogen atmospheres[4].

Flash heating has been used to pyrolyse methane in the presence of 7·5μ tungsten wire; hydrogen, ethane, ethylene, acetylene and carbon were formed[4]. Explosions have been initiated in the systems methane–oxygen and hydrogen–oxygen by flashing these gas mixtures in the presence of borosilicate glass wool. While glass wool is certainly not a simple black-body absorber in triggering these explosions, nevertheless, the glass wool was heated to fusion temperatures[4].

Mineral oil has been flash pyrolysed using suspended molybdenum (less than 74μ) and carbon (less than 36μ) powders, glass wool (8μ) and tungsten wool (7·5μ) as absorbers. Flashing above a threshold energy caused the oil to become black with suspended carbon, effervesce, and fluoresce when excited by 3661-A. radiation. Fig. 4 shows two borosilicate glass tubes of mineral oil flashed once at 10,000 J. The tube with the opaque black suspension contained 25 metres of 7·5-μ tungsten wire, whereas the other had no absorbing material present before flashing. If the solids are filtered from the oil, an absorption spectrum is obtained which is similar to that of an oil degraded in service as a high-voltage insulator.

If a slurry of zinc dust in mineral oil or glycerine is flashed, the metal is evaporated and re-deposited in finer form but without degradation of the matrix. Zinc boils at 907° C.; thus, in the vaporization-redeposition process it must reach a temperature sufficient to pyrolyse the hydrocarbon. Upon flashing zinc dust suspended in polyethylene, zinc was evaporated, but no degradation of the polymer took place. It is possible that the quenching of free radicals by zinc vapour occurs, as in the Paneth mirror removal reaction[7].

Dark particles smaller than 90μ in diameter embedded in polymers become sufficiently hot to cause degradation when flashed above 10^3 J. Carbon, hydrogen, water, carbon monoxide, carbon dioxide, methane, acetylene, ethylene, ethane, and small amounts of higher hydrocarbons are produced when unclean polyethylene is flashed[4,8]. Since the carbon formed with one flash acts as an absorber during the next flash, the amount of degradation in polymers is cumulative with the number of flashes. Empirically, the total amount of gas formed from polyethylene is nearly proportional to the square of the number of flashes[8]. In addition, wax-like degradation products are expelled from the polymer during flashing, and fluorescent materials are deposited near the carbonized centres.

In gaseous or vacuum matrices, absorbing sheets or cylinders, such as wires, fibres or filaments, are the most convenient experimentally since they have known dimensions and shape, are self-supporting, and can be placed in known orientations in the system. Particulate absorbers may be suspended in liquid systems, but for careful work they always show the difficulties associated with agglomeration, poorly known shape, and a distribution of diameters. In very viscous liquids or polymers it is always difficult to incorporate materials without accompanying gas pockets or other disturbances, and reproducibility is never high. In most systems cylindrical absorbers are the most easily handled experimentally.

The experiments described here demonstrate the applicability of rapid heating by flash illumination of absorbers of small dimensions. Further, the similarity of the time-scale and experimental arrangements to the flash photolysis technique[9] suggests its use for preparing free radicals in systems which do not absorb light from the usual flash sources. The chemical effects are somewhat similar to those of shock waves but can be produced in liquid and solid systems as well as gases, to form much greater instantaneous volumes of reaction intermediates. In effect, heating by flash illumination is a heterogeneous sensitization which transfers optical energy from photons unable to cause discrete photochemical processes via thermal excitation into chemical energy, an over-all process quite analogous to true homogeneous sensitization. However, unlike flash photolysis with or without sensitizers, flash heating of absorbing bodies depends little on wave-length of the flash; it often has a threshold intensity below which no discernible reaction occurs, and it has present a hot reactive interface or, in more extreme cases, hot vapour from the absorber, to complicate the reaction.

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DARWINISM AND THE STUDY OF SOCIETY

TO mark the centenary of "The Origin of Species", a conference was arranged at the instigation of the Scottish Branch of the British Sociological Association and held in Adam House, Chambers Street, Edinburgh, during April 8–10. Originally it was envisaged as something of an investigation into the origins and development of Social Darwinism. This intention underwent some change at the hands of the *ad hoc* organizing committee of natural and social scientists from Scottish universities, but the public purpose of the conference emerged as a discussion of the effect of the publication of "The Origin of Species" on social theorizing, and an examination of the present bearing of biology on sociology.

These two main themes became at times closely interwoven, and the core of the conference discussions was, in many ways, Prof. C. H. Waddington's paper on "The Human Evolutionary System". This was nothing less than an attempt to fit Social Darwinism out in modern dress: to read human history and social

development in the light of the biologist's interpretation of evolution.

Waddington began with a concise but extremely lucid exposition of the evolutionary system, under four headings: (1) exploitation, the 'choice' of a particular environmental niche out of the range of possibilities open to any creature, and the possible modification of that environment; (2) epigenesis, the complex and interacting processes by which the development of the fertilized egg into the mature organism is controlled, processes which possess resilience in surmounting obstruction or damage, tend towards the coherent organization of all the single parts, and seek pre-determined end-points of growth; (3) genesis, the transmission of separable hereditary characteristics actually or potentially present in the parents; (4) natural selection, the environmental factors which may favour, challenge, or destroy the possibilities of reproduction. This four-fold system applies, of course, to man as to other animals, but Waddington proposed that it might provide a theoretical model, or at least a number of interesting suggestions, for the interpretation of the evolutionary processes apparent in human history. If one sees the creation of the mature organism from the fertilized egg as a continuous series of chemical accretions and processes going on under controls established by the 'information' stored in chromosomes, then, at this level of abstraction, the theoretical system devised by biologists to account for evolutionary change might conceivably apply to the changes occurring in the more complex, but essentially similar, passage of information from generation to generation of men by a multiplicity of extra-genetic channels.

For example, the genetic make-up of a population tends to resist disturbances which might change it by natural selection; after such a disturbance is withdrawn, the frequencies of genes in the gene pool return towards their previous values. "Something near to this biological genetic homoeostasis in its strict sense . . . are the somewhat nebulous, but often easily recognizable, qualities which are often spoken of as national characteristics, such as Jewishness, or Indianness". Another specific analogy is suggested by the process of introgressive hybridization in plants, which results from the persistence or loss of whole chromosomes. When this happens, a whole "chunk of genetic information", more or less randomly associated, is passed over. The agglomerations of cultural items passed between social groups sometimes appear to be fortuitously associated in a similar way, like trousers with Western technology.

Mr. Maynard Smith's commentary, and the subsequent discussion, fastened on the empirical character of genetic transmission and mutation on one hand, and human history on the other, and not on the conceptual utility of Prof. Waddington's models. Prof. Waddington's picture of an epigenetic landscape formed into watersheds, gullies and valleys by developmental controls is presumably a crude heuristic representation of a very complex process about which, even yet, little is known; it is a way not so much of explaining facts as of keeping what is to be explained in mind. Seen in this light, there is probably something to be gained by a method-starved science like sociology from such broad sketches, taken not as a means of suggesting testable hypotheses but as illustrations of the conceptual strategy employed in a related, and more sophisticated, discipline. Mr. Maynard Smith, however, chose to attack this—and by implication, any other—attempt to work from biological to historical explanation. The material differences he cited are not in dispute: the sub-human evolutionary system works with little or no transference of characteristics acquired metagenetically, whereas there is continuous alteration of social institutions and culture by the interaction of individuals with each other, with their social inheritance, and with their physical environment.

In fact many, if not most, of the sociological analogies quoted in Waddington's paper are very dubious parallels to the genetic and epigenetic models brought into play. The resilience and durability of Jewishness can scarcely be equated with lack of adaptability; this is a familiar sociological instance of cultural adaptation to manifest or latent subordination, along with the well-defined characteristic speech and manners of Negroes in the southern States of the United States: and the association of trousers with steam-engines and trading posts is only non-functional in a very restricted technological sense.

Maynard Smith took the view that the Marxist interpretation was the best attempt so far made at a usable theory of history, its weakness lying not in any fundamental error in Marx's own approach but rather in the failure of his followers to treat his ideas critically or to modify them in the light of advances in other fields. He did not think that one could usefully start from evolutionary theory and then attempt to find historical analogies for the various entities and items involved. Prof. Waddington, he said, had failed to point to any process in history comparable to natural selection, the most important single concept in the theory of evolution.

I have little doubt that a quick glance through the record of patented inventions, or the history of revolutionary epochs in England, France and Russia, even a reading of "Doctor Zhivago", would reveal plenty of instances of natural selection at work in the field of technological or political innovation. The crux of the difficulty lies, as Dr. J. Bronowski hinted at the end, in our present incapacity to isolate a single 'billiard-ball' entity from which to build explanations of variation in human society, as biologists have done with the gene—the unitary member of a pool of available characteristics constantly replenished by mutation and reduced by natural selection.

For Bronowski, this represented a failure by sociologists to respond to the challenge of Darwin's work. It was a double challenge, and a double failure. The first was the implicit question in his work of how variation occurred, a question which the later science of genetics was developed in order to answer. The second was the introduction of the notion of chance into rational explanation. This had, he claimed, proved a necessary foundation for the future not only of biology but also of physics.

In reality, chance has figured very largely in the historian's rendering of his subject. It accounts partly for the outlawing of pattern, interpretation, and theory by historians, and becomes explicit, though disguised, in the remark of H. A. L. Fisher's, quoted with such approval by K. R. Popper: "Men . . . have discerned in history a plot, a rhythm, a predetermined pattern . . . I can see only one emergency following upon another . . . only one great fact with respect to which, since it is unique, there can be no generalisations". But historians have used chance as a flag of surrender rather than as a weapon, and students of society have been content to name tendencies rather than establish laws. Prof. Morris Ginsberg's paper, "Social Evolution", was itself an

admirable demonstration of the classic procedures of sociologists, and of the very different manner in which they have developed the concept of evolution and met the questions it poses. It discussed at some length attempts by nineteenth-century and later social scientists to develop evolutionary interpretations of the course of development of language and technology, and less successfully, of religion and law. He then presented his own view of social evolution as a process of development through higher levels of organized complexity of rational ideas, this process being effected by the human capacity for the intercommunication of ideas and skills.

Prof. Lancelot Hogben, by contrast, made his contribution on "Darwinism and Human Society in Retrospect" an exercise in the interpretative view of history he has made his own—which one would like to call philotechnic commensalism: the fortuitous concurrence and subsequent interaction of circumstances, generating complex causal processes which determine the direction and the variations in the rate of cultural development in different sections of the human species. The technological backwardness of the African is thus related to the susceptibility of horses to trypanosomiasis, which "has condemned Africans south of the tropic of Cancer to be their own beasts of burden in territories where malaria, yellow fever, hook-worm infection, schistosomiasis and many other diseases only lately recognized by medical science exact a heavy toll from the vitality of the people". Furthermore, "every change of the human environment through human interference signalizes a new accretion of transmissible experience and a new potential of further change. Because of this, human society is a unique ecological system". Thus, Darwin's work fits logically into its historical position when seen in the context of the stage reached by technological developments available in England by the mid-nineteenth century; the most significant circumstances being the greater facilities for sea travel offered by steam power, which "both greatly enlarged opportunities for a global survey of living beings and forced the problems of geographical distribution on the attention of naturalists", the accumulation of evidence for evolutionary succession provided by the work of survey and excavation undertaken during the railway-building period, and the major improvements in the microscope. The formulation and reception of Darwin's contribution to evolutionary theory similarly falls into place among the controversies over the criteria which should determine admission to the universities, the Civil Service, commissioned rank in the army and other controllerships, the debate over free competition as a principle of economic welfare and a social ethic, and the re-sharpening of the Abolitionist conflict in the years before the outbreak of the American Civil War.

In turn, the grand theological debates of the next forty years appear now to be locked firmly within their ideological setting; and the fruitless search for a complete genealogy of organic creation, Hogben also suggested, is visible now as the inescapable fate of a biology unprovided with the means of distinguishing adequately between hereditary transmission and genetic variation.

While Hogben's and Waddington's contributions inevitably dominated the conference, as latter-day reflexions by Darwin's scientific successors on the possibilities and limitations of a biological view of human society, other topics bulked larger than this short notice can easily show. Prof. Basil Willey's introductory account of the descent of Darwin's own theories from previous writings, although stretching back to Empedocles, was subject to a good deal of emendation in later discussions; his restriction of the effect of his work to the theological debate was deplored, and his view of Darwin's ultimate religious position as "helping to restore buoyancy to religion by forcing it to abandon some of its more untenable defences" was rejected by both *rapporteurs*. His paper also, however, bore on Darwin's introduction of the notion of chance into the rational interpretation of universal destiny, ideas far more disruptive than Newtonian mechanics, which had made the retention of the notion of design and of Designer plausible.

Mr. S. A. Barnett, in the last session, returned to the attack on Prof. Waddington's side with a range of suggestions from the study of the behaviour of bees, rats, birds and fish which might throw some light on behaviour in infancy, on motivation or emotion, and on the nature of language and human communication in general. Mr. Tom Burns, in the final paper, regarded these suggestions as limited to a very small field of human conduct, which characteristically selected courses of action from the wide range of possibilities available as normative guides to members of any society.

At the close of this conference, Dr. Bronowski remarked that no title could have lent itself better to so diverse an array of papers on such different subjects. Survivors of conferences on cybernetics may dispute this, but a conference which began with observations on the "history of man's endless probings into the mystery of existence; his thoughts about the nature of reality, about the administration of the universe . . ." and ended with a muted discussion on chance as the mechanism of irreversibility, and thus as the instrument of the universal order apprehended by man, has some claim to catholicity. It was also, far more frequently than one expects any conference to be, absorbingly interesting and seminal.

The conference papers will be published in book form.

TOM BURNS

OBITUARIES

Dr. L. J. Spencer, C.B.E., F.R.S.

LEONARD JAMES SPENCER, who died on April 14 at the advanced age of eighty-eight, was fourth in a line of distinguished keepers of minerals in the British Museum. His predecessors were Story-Maskelyne, appointed the first keeper of the department a century ago, Sir Lazarus Fletcher and G. T. Prior. All three were Fellows of the Royal Society, to which Spencer also was elected in 1925. He was made C.B.E. in 1934, he was given the Murchison Medal of the Geological Society in 1937, and the Roebling Medal of the Mineralogical Society of America in 1941. He was an honorary member of the Mineralogical Societies of Germany and of America, a senior Fellow of the Geological Society of London, and was president of the Mineralogical Society during 1936–39, and its foreign secretary from 1949 until his death.

Spencer was born at Worcester on July 7, 1870, the eldest son of James Spencer, for many years headmaster of the Day School Department of Bradford Technical College. According to a note in a local paper on the occasion of his appointment to the British Museum, he was "nurtured on examinations" and "when he had just completed his seventh year he turned his serious attention to geology . . .". From Bradford he went with a Royal Exhibition to the Royal College of Science for Ireland, taking a first in chemistry. Thence with a scholarship he went to Sidney Sussex College, Cambridge. He won the Harkness Scholarship in 1893 and successfully competed for a vacancy in the Department of Mineralogy in the British Museum (Natural History) in the same year. He then went for six months to Munich to study under Paul Groth, using his Harkness Scholarship money for the purpose, and returning to take up his appointment at the Museum on January 1, 1894. He married in 1899 Edith Mary, daughter of Islip J. Close, of Mortimer, Berkshire, and leaves a son and two daughters.

Spencer's main achievement in the Department of Mineralogy, apart from his scientific research work, was the establishment of the system of registration, labelling and card-cataloguing the mineral collection. After Prior became keeper in 1909, Spencer did a great part of the registration himself, and one result of his work and of his careful training of those who followed him is that the National Collection of Minerals is now probably the best documented and indexed in the world.

In addition to all his meticulous work on the collection, Spencer's output of original papers was considerable. His publications number well over a hundred and range over a wide field of descriptive mineralogy. He published two books, on minerals and on precious stones, and he translated from the German two large quartos on the same subjects. He took up the study of meteorites after Prior's retirement in 1927 and contributed many papers on this subject to the *Mineralogical Magazine*.

The discovery of the meteorite craters at Henbury in Australia and Philby's discovery immediately afterwards of the crater at 'Wabar' with its slag-like masses of silica-glass black with included millions of tiny spheres of nickel-iron gave great impetus to Spencer's work in this field and led him also to take up the problem of the origin of tektites. He strongly advocated the theory that tektites are the product of the impact of great meteorites on the Earth's surface, a theory that still finds many supporters but remains unproved. It was his interest in these problems that led him at the age of sixty-four to accompany an expedition into the heart of the Libyan Desert to investigate on the spot the masses of yellow silica-glass discovered in 1932 by P. A. Clayton. He hoped to find a meteorite crater there, but returned with the problem of the origin of the glass still a mystery. Spencer retained a very active interest in meteorites right to the end of his life, and his very last publication on meteorites was a communication in *Nature* of March 8, 1958.

Spencer's work at the British Museum would have filled the working life of some men, but he seemed always to be doing the work of three. In 1901 he took over the editorship of the *Mineralogical Magazine* from Miers, and he continued to edit it until the end of 1955. Previous to 1901 he had catalogued mineralogical papers for the Royal Society Catalogue for 1883–1900, and he continued this for the International Catalogue of Scientific Literature for 1901–14. In 1920 the Mineralogical Society commenced publication of *Mineralogical Abstracts*, and Spencer edited it and prepared more than half the abstracts himself. When he retired he had edited twelve volumes covering thirty-six years. A dinner in his honour was given him by his friends in November 1950 on the completion of his fifty years as editor of the magazine, and he lived to see *Mineralogical Abstracts* appear in a new format as a joint British–American publication aiming at a still wider international coverage of the science.

W. Campbell Smith

Dr. Eric Berkeley Higgins

Dr. Eric Berkeley Higgins, who died suddenly on April 8 at the age of seventy-three, was an inventor of the classical industrialist type, which pioneered industrialism, and is still not quite extinct. He had the peculiar flair for chemical development which seems to combine art and science. After early success with Dr. Ormandy, he invented the use of nickel formate in the hydrogenation of oils, and found his capitalist in Hamburg, where he was busy getting the process started when the First World War broke out.

Higgins was arrested in November 1914, and became one of a large number of Englishmen collected, under very unpleasant conditions, from all over Germany. These finally arrived in the Ruhleben racing stables at Spandau, where most of them stayed for the duration of the War, under the supervision of neutral diplomats. The American ambassador soon condemned one barrack (twenty-four horse boxes with hayloft above) as unfit for human habitation, so this was handed over to the already very active representatives of the arts and sciences among the prisoners. The scientists included established research men in physics, chemistry and biology, one of whom eventually became a Nobel prizeman. Soon a laboratory for teaching and research in all these branches came into existence, and Higgins was one of its most active spirits. He had arrived at the camp with two young men just gazetted out of Woolwich, with a sound mathematical training but no science. Higgins made them both change to science as a career, and one of them received his knighthood for it.

The power which Higgins had to enthuse gifted youth, and gain their warm personal regard, played no small part in his subsequent success, which culminated in Catomance, Ltd., which he worked up from small beginnings on his inventions in waterproofing and mothproofing materials. When he showed the latter some years ago at a chemical exhibition in London, he directed attention to it by providing a few live moth grubs engaged in chewing wool, with a microphone and loudspeaker which made them audible to visitors. This naturally appealed to the B.B.C. reporter touring the exhibition, and all the world heard the nasty little fellows munching.

Higgins had a mind the energy of which seemed entirely undiminished by several spells of ill-health. He would be at it hammer and tongs, first at Liverpool making soap, then at Brentford on water-softening compounds and naphthol *AS* dyes, then at Welwyn Garden City on the intensive development work which brought prosperity. He enjoyed to the end the affection of the men and women who formed the firm which he created, and all his life-long friends.

H. Stafford Hatfield

TABLE OF ARTIFICIAL EARTH SATELLITES

From the Royal Aircraft Establishment, Farnborough, Hants. May 8, 1959

Name	Launch date, life-time and descent date	Shape and weight	Size	Date	Orbital inclination (deg.)	Orbital period (min.)	Perigee height (n. miles)	Apogee height (n. miles)	Orbital eccentricity	Argument of perigee (deg.)
•*Sputnik* 1 1957α2 instrumented sphere	1957 Oct. 4·8 ? 92 days ?1958 Jan. 4	Sphere 184 lb.	23 in. dia.	1957 Oct. 4·9 1957 Oct. 25·8 1957 Dec. 25·1	65·1 65·1 65·0	96·2 95·4 91·0	122 120 110	513 471 254	0·052 0·047 0·020	58 49 23
•*Sputnik* 1 1957α1 rocket	1957 Oct. 4·8 57 days 1957 Dec. 1	Cylinder? —	—	1957 Oct. 4·9 1957 Nov. 4·0 1957 Nov. 24·3	65·1 65·1 65·0	96·2 94·0 91·0	122 119 110	513 403 254	0·052 0·038 0·020	58 45 36
•*Sputnik* 2 1957β	1957 Nov. 3·1 162·0 days 1958 Apr. 14·08	Payload 1,120 lb.	? 70 ft. long	1957 Nov. 4·00 1958 Jan. 4·00 1958 Feb. 21·00 1958 Mar. 25·00 1958 Apr. 9·00	65·33 65·29 65·26 65·23 65·21	103·760 100·505 97·105 93·785 90·780	122 119 114 107 97	902 739 570 402 253	0·0987 0·0802 0·0605 0·0400 0·0215	59 35 14 359 352
Explorer 1 1958α	1958 Feb. 1·16 4 years	Cylinder 30·8 lb.	80 in. long 6 in. dia.	1958 Feb. 1·16 1959 Jan. 3·05 1959 Mar. 21·06	33·2 33·2 33·1	114·8 111·7 111·2	191 189 189	1,379 1,228 1,203	0·141 0·125 0·122	121 139 296
Vanguard 1 1958β2 instrumented sphere	1958 Mar. 17·5 ? 100 years	Sphere 3¼ lb.	6·4 in. dia.	1958 Mar. 17·5 1959 Mar. 12·5	34·3 34·3	134·18 133·94	353 353	2,140 2,129	0·191 0·190	129 274
Vanguard 1 1958β1 rocket	1958 Mar. 17·5 ? 100 years	Cylinder 50 lb.	4 ft. long 20 in. dia.	1958 Mar. 17·5	34·3	134·18	353	2,140	0·191	129
•*Explorer* 3 1958γ	1958 Mar. 26·73 93 days 1958 June 28	Cylinder 31 lb.	80 in. long 6 in. dia.	1958 Mar. 26·73 1958 May 15·0 1958 June 14·13	33·3 33·3 33·3	115·7 104·8 96·8	101 97 93	1,511 970 565	0·166 0·110 0·063	326
Sputnik 3 1958δ2 instrumented cone	1958 May 15·3 19 months	Cone 2,926 lb.	12·3 ft. long 68 in. dia.	1958 May 15·3 1958 Nov. 17·00 1959 Mar. 2·9	65·19 65·16 65·13	105·97 103·000 100·750	122 120 118	1,015 867 754	0·111 0·095 0·082	58 351 310
•*Sputnik* 3 1958δ1 rocket	1958 May 15·3 202·4 days 1958 Dec. 3·7	Cylinder? —	— —	1958 May 15·3 1958 Aug. 15·10 1958 Oct. 11·25 1958 Nov. 13·66 1958 Nov. 30·59	65·19 65·14 65·09 65·04 65·00	105·9 102·000 98·000 94·000 90·000	122 119 115 108 95	1,011 816 615 413 217	0·111 0·089 0·066 0·041 0·017	58 26 5 347 339
Explorer 4 1958ε	1958 July 26·63 13 months	Cylinder 38·5 lb.	80 in. long 6 in. dia.	1958 July 26·63 1958 Oct. 25·06 1959 Mar. 21·02	50·3 50·3 50·2	110·18 107·73 102·37	142 140 138	1,193 1,073 805	0·128 0·115 0·085	50 317 60
•*Atlas* 1958ζ	1958 Dec. 18·96 33·6 days 1959 Jan. 21·6	Cylinder 8,700 lb.	80 ft. long 10 ft. dia.	1958 Dec. 18·96 1959 Jan. 1·78 1959 Jan. 17·02	32·4 32·4 32·3	101·47 98·12 92·67	104 95 88	796 627 355	0·089 0·070 0·037	130 249 37
Vanguard 2 1959α1 instrumented sphere	1959 Feb. 17·67 ? 50 years	Sphere 21·5 lb.	20 in. dia.	1959 Feb. 17·67	32·9	125·7	301	1,790	0·166	135
Vanguard 2 1959α2 rocket	1959 Feb. 17·67 ? 50 years	Cylinder 50 lb.	4 ft. long 20 in. dia.	1959 Feb. 17·67	32·9	130·0	302	1,992	0·184	135
•*Discoverer* 2 1959γ	1959 Apr. 13·89 13 days 1959 Apr. 26·5?	1,300 lb.		1959 Apr. 13·9 1959 Apr. 24·6	90 90	90·4 88·9	130 103	190 132	0·008 0·004	160 96

NOTES: Dates are given in days and decimals of a day U.T. 1 nautical mile = 6,080 ft. = 1·853 km. Perigee and apogee heights for *Sputniks* are over an earth of radius 3,435 n.m. and for U.S. satellites over an earth of 3,442 n.m. Argument of perigee is the angle from northward crossing of the equator to perigee, measured along the orbit. The orbital values for the *Sputniks* are from British observations and theory. Those for the U.S. satellites have been compiled from a variety of sources. It is not known whether *Discoverer* 1, launched February 28, 1959, achieved orbit; it was, nevertheless, designated 1959β. • Indicates satellites no longer in orbit.

NEWS and VIEWS

International Meteorological Organization Prize, 1959 : Prof. J. Bjerknes

THE Executive Committee of the World Meteorological Organization has this year awarded the annual prize, provided by funds left by the International Meteorological Organization on the formation of the World Meteorological Organization, to the eminent Norwegian meteorologist, Prof. J. Bjerknes, who is now professor of meteorology at the University of California, Los Angeles. Prof. Bjerknes is known to meteorologists everywhere for his work, in conjunction with his father, the late V. F. K. Bjerknes, T. Bergeron and H. Solberg, in the initiation forty years ago at Bergen of the technique of frontal and air-mass analysis in weather forecasting. With the same meteorologists as those noted above, he collaborated in the writing of a major text-book on dynamical meteorology, "Physikalische Hydrodynamik", published in 1933. Before the War he carried out much research into the structure of depressions, as revealed by the release of a large number of sounding balloons at frequent intervals from one place for a number of hours, and with the dynamics of convection in the atmosphere. Since the War he has been particularly concerned with research into the general circulation of the atmosphere. He was professor of meteorology at the Geophysical Institute in Bergen from 1919 until 1931 and went to Los Angeles in 1940. In international scientific work he has been both secretary and president of the Association of Meteorology of the International Union of Geodesy and Geophysics. British meteorologists, to whom he is well known as an honorary Fellow (1932) and Symons Gold Medallist (1940) of the Royal Meteorological Society, welcome this award to one of their most distinguished, genial and unassuming colleagues.

Chemistry in Relation to Medicine at Edinburgh : Prof. G. F. Marrian, F.R.S.

PROF. G. F. MARRIAN, who is to retire from the chair of chemistry in relation to medicine in the University of Edinburgh, moved from Toronto to Edinburgh in 1938 to succeed Prof. George Barger. He had already established his reputation by the isolation of pregnanediol in 1929, œstriol in 1930 and œstriol glucuronide in 1936. He gathered a group of workers and proceeded to isolate a considerable number of new products of steroid metabolism, notably 16α-hydroxyœstrone, and more recently he has also worked on the metabolism of adrenal cortical hormones. He developed new methods of estimation of steroids of clinical importance for diagnostic purposes. On his advice, the Medical Research Council set up a Clinical Endocrinological Research Unit at Edinburgh and he took a considerable part in its management and direction. Latterly he served on the Agricultural Research Council, the Medical Research Council and the Advisory Committee for Medical Research in Scotland.

With the institution of a six-year curriculum at Edinburgh in 1949, Marrian took over the teaching of biochemistry to medical students. For them his lectures provided an exceptionally clear and illuminating introduction to the subject. After a few years, the teaching of chemistry to medical students, which was previously the Department's main teaching duty, was handed over to the Department of Chemistry, so enabling the Department of Biochemistry to undertake the teaching of biochemistry to dental and to veterinary students and to strengthen the science courses in biochemistry, which now include a flourishing honours year.

Prof. R. B. Fisher

DR. R. B. FISHER, who is to succeed Prof. Marrian at Edinburgh, took the Final Honour School of Animal Physiology in the University of Oxford in 1929, became a departmental demonstrator immediately and a University demonstrator in due course. For more than twenty-five years he was one of the most sought-after teachers of biochemistry in Oxford. Undergraduates reading medicine learned from him a critical approach to the literature and an eye for nonsense which left a permanent stamp upon them. Colleagues in many biological departments made a habit of asking for his criticism and advice on their papers, on their design and statistics. He did the same useful service officially as an editor both on the *Journal of Physiology* and the *Biochemical Journal*. He was away from Oxford for some years during the Second World War, directing an Air Ministry Group concerned with the design and analysis of strategic bombing. He belongs to the select race of chemical physiologists, and prefers to work on unquestionably living cells. He has demonstrated creatine synthesis in the surviving heart, and is using the perfused heart for work on the effects of insulin on permeability. He devised a method of studying absorption in surviving small intestine and has written a book on "Protein Metabolism", which is widely known as a critical appraisal of accepted views.

Fisheries Research : Dr. H. A. Cole

DR. H. A. COLE, who took up his duties as director of fisheries research on May 1, in succession to Mr. R. S. Wimpenny (see *Nature*, 181, 159 ; 1958), joined the Ministry of Agriculture, Fisheries and Food as an assistant naturalist in 1933 when he was appointed to the Laboratory at Conway. During the period up to the war he was largely concerned with an examination of the development and setting behaviour of oysters in tanks and of the incidence of parasites. In the war he was seconded to the Yorkshire (West Riding) War Agricultural Executive Committee, serving as a deputy chief executive officer. When he returned to the Conway laboratory in 1946 he resumed and extended his interests in oyster culture in a manner which rapidly made him an outstanding authority in his field. Plans for the rehabilitation of oyster beds which arose from this work resulted in the establishment in 1953 of a new fishery laboratory at Burnham-on-Crouch largely devoted to this purpose. Dr. Cole succeeded the late Mr. R. E. Savage at this juncture as head of the Shellfish Section, with his headquarters at the new laboratory. From here he and his staff produced much valuable advice on the cleansing and rearing of shellfish and initiated a considerable amount of

U.S. satellites : Dates are given in Greenwich mean time and decimals of a day; thus 149.5 means midday on May 29. Inclination of orbit is the angle from northward crossing of the equator to perigee, measured along the orbit. The orbital values for the *Sputniks* are from British observations and theory, and those for the U.S. satellites have been compiled from a variety of sources. It is not known whether *Discoverer* 1, launched February 28, 1959, achieved orbit ; it was, nevertheless, designated 1959ϕ. * Indicates satellites no longer in orbit.

development work on culture and pest control. In addition to this Dr. Cole found it possible to foster a substantial amount of new research work. This included, besides the nanoplankton food of the larval oyster, investigations into the natural history and exploitability of cockles, clams, whelks, scallops, shrimps, crabs and lobsters. When the International Council for the Exploration of the Sea founded its Shellfish Committee Dr. Cole was appointed the English representative. For the past three years he has served as the chairman of this body, effecting a useful integration of the several national programmes and working successfully towards standardization of methods. In 1954 he was offered the Buckland Professorship, choosing for his series of lectures the title "Inshore Fisheries", and in February 1958 he was appointed deputy director of fisheries research.

Mr. R. J. H. Beverton

Mr. R. J. H. Beverton, who succeeds Dr. H. A. Cole as deputy director of fisheries research in the Ministry of Agriculture, Fisheries and Food, joined the Fisheries Laboratory, Lowestoft, as a scientific officer in 1945. Having taken a first in zoology in Part 2 of the Natural Sciences Tripos at Cambridge and the Frank Smart Prize as best student of the year, he devoted a good knowledge of mathematics and his sympathy for this subject to considering a mathematical formulation of fish stocks under the influence of fishing. Working in the Population Section under Mr. Michael Graham he quickly developed the subject, and in conjunction with Mr. S. J. Holt, now of the Food and Agriculture Organization, has produced a manual on the subject of population dynamics of fish species which is a classic and which has made him a world authority in this field. During the past ten years he has produced numerous papers and memoranda and his advice, offered directly or indirectly to international bodies such as the Permanent Commission of the 1946 Fisheries Convention, the International Council for the Exploration of the Sea, and the International Commission for the Northwest Atlantic Fisheries, has made his position as an adviser on fisheries conservation quite outstanding. In addition to this he has twice been called on to visit and report on the fisheries of the Colonial dependencies; in the first instance Lake Victoria Nyanza and in the second the sea fisheries of the Kenya and Tanganyika coasts. He has also been twice invited abroad to give a course of lectures on his subject, once in the United States and once in Canada. Mr. Beverton succeeded Mr. Michael Graham as head of the Population Section at Lowestoft when the latter retired in February last year. In addition to the very considerable volume of direct research work on which he is engaged, Mr. Beverton has been responsible for developing the collection of research statistics and fish measurements at the ports on a scale that has not been equalled elsewhere.

Kalinga Prize: Prof. Karl von Frisch

Prof. Karl von Frisch, of Munich, the eminent zoologist, well known for his research on the sensorial physiology of insects and fish, has been awarded the Kalinga Prize for popularization of science. The prize of £1,000 is offered annually by the Kalinga Foundation, which has been set up to contribute to the economic, social and cultural progress of the Indian State of Orissa. The purpose of the award, as stated by Mr. B. Patnaik, its donor, is to offer recognition to leading interpreters of science and also to strengthen links between India and scientists of all nations.

Space Research in Britain

Following the Prime Minister's statement on the British space research programme, in the House of Commons on May 12, the Lord President of the Council has appointed a Steering Group on Space Research, under the chairmanship of Sir Edward Bullard, with the following terms of reference: "Subject to the responsibility of the Lord President of the Council, in consultation with the other Ministers concerned, for the supervision of the Government's Space Research Programme, to advise on the formulation of that programme, and to co-ordinate the arrangements for its execution".

The membership of the Group is as follows: Sir Edward Bullard (*chairman*); Prof. W. V. D. Hodge, secretary of the Royal Society; Prof. H. S. W. Massey, University College, London; Sir Harry Melville, secretary, the Department of Scientific and Industrial Research; Sir Graham Sutton, director-general of the Meteorological Office; Dr. R. van der R. Woolley, Astronomer Royal; and senior officials representing other interested government departments. The Steering Group had its first meeting on May 27.

Space Monkeys

On May 28 two monkeys were recovered unhurt from the nose cone of an American Jupiter missile after a space-flight of 1,500 miles. The flight lasted about 15 min.; the missile reached an altitude of about 300 miles and attained speeds of up to 10,000 m.p.h. During the flight reports of the monkeys' heartbeats, muscular reactions, pulse, temperature and respiration were, among other things, relayed back to Earth. The animals seem to have been little affected by the violent acceleration and the 9-min. period of weightlessness which they experienced. They will probably appear on television. The nose cone also carried samples of yeast, corn, mustard seed and fruit-fly larvæ, and, in order to study the effect of weightlessness on the processes of fertilization, phials of the eggs and sperm of sea-urchins which were mixed when the missile attained its maximum velocity.

Department of Scientific and Industrial Research Committee on Metal Fatigue

A committee to review current research needs on the fatigue of engineering structures and to survey existing research facilities has been set up by the Council for Scientific and Industrial Research following an approach from the Institution of Civil Engineers. The committee will not include aircraft structures, reinforced concrete structures, or metal physics in the scope of its review, though information gained in these fields will be used. Sir Alfred Pugsley (University of Bristol) has been appointed chairman. The other members of the committee are: Sir Donald G. Bailey, Mr. T. Baldwin, Mr. H. L. Cox, Mr. O. A. Kerensky, Mr. H. M. Pemberton, Mr. C. E. Phillips, Prof. S. C. Redshaw, Dr. P. B. Walker and Dr. R. Weck. The committee's terms of reference are: "to review current research needs on fatigue of engineering structures (metal), to survey existing research facilities and to make recommendations to the Department of Scientific and Industrial Research". The committee is interested in examining records of failures or accidents which might have been due to

structural fatigue, even if fatigue was not recognized as the initial cause. Such information may be helpful in revealing areas in which further research work is needed.

Regional Technical Information Services

In reply to a question in the House of Commons on May 12, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, said that the Department of Scientific and Industrial Research was helping active local organizations to build up regional technical information services based on Birmingham, Bristol, Cardiff, Manchester and Newcastle-upon-Tyne, and the staffs of these centres put firms in touch with sources of information. The contact was made by actual visits from the research centres and by the normal Press reports and brochures. In answer to another question, Mr. Nicholls said that from the research reports on social and psychological research in industry, the Department, with the agreement of the Medical Research Council, had selected twelve projects as suitable for presentation in a short and popular form, and three of these had already been published by H.M. Stationery Office.

International Cultural Affairs

In a debate on the international situation in the House of Lords on May 4, Lord Aberdare stressed the value of university scholarships and exchanges in furthering international understanding, and urged the Government to consider increasing its present grant of £6,000 a year to the European Cultural Fund which at present has an income of only £32,000 a year. Lord Lansdowne, in replying for the Government on the debate, made no comment on this proposal, which was also advanced in an adjournment debate in the House of Commons on May 1. In the House of Commons, Mr. R. Allan, the joint Under-Secretary of State for Foreign Affairs, said that the Government was playing its part in the cultural work of the Council of Europe and was anxious to take it further. It did not exclude the possibility of a further voluntary government contribution, but wished to see first what could be done from private sources, as had been suggested by Mr. H. Delargy and Mr. R. Russell in opening the debate.

Beit Memorial Fellowships

The Trustees of the Beit Memorial Fellowships for Medical Research in their report for 1958–59 announce that Sir Francis Glyn has been elected a Trustee and honorary treasurer of the Trust; that Dr. Honor B. Fell has been appointed to the Advisory Board in place of Prof. J. H. Gaddum, who retires after fifteen years service; and that Sir Roy Cameron has been appointed secretary of the Trust in place of Prof. A. A. Miles, who retires from the secretaryship after seven years service.

The following elections have been made.

Junior Fellowships. Dr. W. D. Stein, to study the mechanism of specific transport systems across cell membranes at the molecular level, with special reference to the components concerned in the movement of glycerol across the human red blood cell membranes; at the Department of Colloid Science, University of Cambridge. Dr. G. Burnstock, to study the action of drugs on smooth muscle and the effect of autonomic nerve stimulation on the membrane potential recorded from smooth muscle cells; at the Department of Pharmacology, University of Oxford. G. L. Asherson, to study the causation of rheumatoid arthritis, systemic lupus erythematosus and other diseases in which antibodies against human and animal tissue can be detected; at the Rheumatism Research Unit (Medical Research Council), Canadian Red Cross Memorial Hospital, Taplow. E. R. Huehns, to study the hæmoglobins and the non-hæm proteins in normal and abnormal human red blood cells, with the view of distinguishing thalassæmia from the hæmoglobinopathies; at the Department of Biochemistry, University College, London. C. T. G. Flear, to study sodium–potassium exchange in tissues during induced congestive heart failure, and its bearing on the therapy of congestive heart failure in man; at the Department of Experimental Medicine, University of Cambridge.

Fourth Year Fellowships. T. F. Slater, to continue the study of the enzymic constitution of the rat mammary gland in relation to lactation; at the Department of Biochemistry, University College, London. Dr. J. R. Tata, to continue the study of normal and abnormal pathways of metabolism of thyroid hormones; at the National Institute for Medical Research, Mill Hill, London.

Presenting Science to the Public

An article by Prof. P. M. S. Blackett, reprinted from *Progress* of May 1958, appears under the title "The British Association Looks Ahead" together with two short notes on presenting science to the public in *The Advancement of Science* for March 1959. Prof. Blackett, starting with a brief historical survey, indicates some of the ways in which the British Association is seeking to play a wider part in the interpretation of science to the nation, and the three main aspects of modern science with which the Association must concern itself in so doing. The following note describes the work of the three area committees established at Newcastle, Durham and on Teeside, the lecture service, particularly for school audiences, the educational programme for young people under sixteen and the rapid development of the work of the Metric Committee and of the study group on the education of the graduate scientist in schools and universities. The third note describes the progress made in the preliminary survey of existing visual aids in relation to the Young People's Programme requested by the Visual Aids Committee in November 1958. The Young People's Programme is based on three main assumptions: that the most effective single weapon would be a magazine designed to present science attractively and authentically to young people; that it is also necessary to give the schools all possible help; and that the Science Clubs will require all possible assistance, including visual aids. It is believed that the Association would perform a major service by providing an impartial survey which outlined the role of existing agencies, published comments by those working in the field on the use and suitability of existing aids; and recommended, after consultation with existing agencies and individual experts, action to promote the better use of the material available as well as the production of new material.

Lecture Theatre proposed for the Royal Aeronautical Society

The Hyde Park Corner reconstruction scheme has provided the Royal Aeronautical Society with a unique opportunity for building a much needed lecture theatre at the back of its headquarters at

4 Hamilton Place, London, W.1. The new Apsley carriageway cutting across the corner of the Park is to be started soon and will give access to the site, but only while the road is under construction. The Society has seized this chance to launch an immediate appeal for the £150,000 needed to build and furnish a theatre seating more than 300. The detailed plans are completed and open to inspection. All planning permissions are assured and it is hoped to start work this September. Donations should be sent to the Secretary of the Society at the above address.

Ultrasonic Vibrations at 10,000 megacycles

An announcement by the International General Electric Co., of New York, reports that one of its scientists, Dr. E. H. Jackson, has been able to produce ultrasonics at the enormous frequency of 10,000 megacycles per second. Up to the present, the limit of frequency has been about 200 megacycles per second, obtained from one of the high harmonics of a thin slice of quartz, excited piezoelectrically. Details of Dr. Jackson's method are not given, but it appears that a quartz crystal is combined with a cavity resonator in such a way as to excite it at a high frequency. The usual difficulty with such a device is to avoid the crystal jumping from one harmonic to another, but to prevent the ultrasonic energy degenerating into that associated with thermal vibrations in the material, the crystal is kept at 2° K. It is proposed to use the source to investigate the energy-level of atoms and the interactions of electron spins in a crystal lattice. Another useful application—if the vibrations can be kept 'pure'—should be to study the absorption and velocity of ultrasonics in fluids with the view of finding very short relaxation times in the transfer of energy between the degrees of freedom of the molecules.

South African Museum

The success of a museum as an educational centre is to a large extent dependent on a competent professional staff. The report of the South African Museum for 1957–58 (pp. 19. Cape Town: South African Museum, 1958) indicates that three posts for professional officers and a taxidermist which had been allowed to lapse have been revived and a new post of historian established. It is hoped that the creation of the latter post will lead to the formation of a Cultural-historic Museum in Cape Town. A new store has been built and the Museum is now in a position to accept historical material for safe keeping and subsequent exhibition. Unfortunately the staff are so fully occupied with normal curatorial work that they have little time for research, a function which is essential for the full development of a museum. The report includes notes on five new inscribed stones recently discovered on the site formerly occupied by the General Post Office in Cape Town.

A New Field Centre

The Field Studies Council is planning to open a sixth Field Centre during 1959. In co-operation with the Herbert Whitley Trust, a building and land are being acquired at Slapton in South Devon, and, in the first place, it is hoped to provide facilities for about thirty students. The Council has designated Mr. Ian Mercer, formerly assistant warden at Juniper Hall Field Centre, to the warden's post at the new centre. The property is situated at the seaward end of Slapton village about 400 yd. from the shingle of Start Bay. Behind the shingle bank are two large freshwater lakes—the Leys—which, together with Slapton Wood and France Wood, constitute a Nature Reserve which will be leased to the Field Studies Council by the Herbert Whitley Trust. There is considerable opportunity for biological fieldwork. It is hoped that the Centre can be opened for small parties in the near future and more fully from July 1, 1959.

Besides the new Centre, the annual report for 1957–58 (pp. 28+4 plates. London: Field Studies Council, 1959) describes the continued growth and public demand for the existing Centres. Unlike previous issues, the annual report contains no scientific papers. In future, these are to be published independently under the new title, *Field Studies*. The first issue will include papers on the mollusca of the Flatford area; the insects of the Malham area; the geography of the Alberbury breccia; and the geomorphology of the Tillingbourne.

Architectural Science Review

Building is one of the traditional occupations of mankind which has become the subject of organized scientific inquiry only in comparatively recent times. In the early stages of research on building, attention was concentrated on the materials and constructions used, but latterly increased attention has been given to the overall problems of design. It is precisely with the scientific basis of architecture in the narrow sense of design for function that the new Australian journal, *Architectural Science Review*, is concerned (1, No. 1. Pp. 56. Three issues per year. Annual subscription, post free, 42*s*. (Australian); single copies, 15*s*. Academic Press Proprietary, Ltd., Sydney, Australia). The general scope of the *Review* is illustrated by the papers in the first issue and by the titles proposed for the second. In the first issue there are papers concerned with thermal comfort zones, the weathering of buildings (with particular reference to curtain walls), the design of structures with the aid of models, building in the tropics, and daylighting design. In addition, a selective bibliography on climate and architecture is given. For the second issue, papers on the Australian climate, on lifts and escalators, and on high-alumina cements are proposed, in addition to two further papers on lighting and insolation. The *Review* promises to provide a focus for the publication of researches which at present are scattered in numerous scientific and architectural journals. A new journal covering the field is to be welcomed, and it may well attract papers from outside Australia.

Kanamycin

The New York Academy of Sciences has recently published, in the form of a monograph, laboratory and clinical results obtained with kanamycin in various centres in North and Central America (*Ann. N.Y. Acad. Sci.*, **76**, 11; 1958. Article 2: The Basic and Clinical Research of the New Antibiotic, Kanamycin. By Maxwell Finland and 93 other authors. Pp. 17–408). Kanamycin is yet another *Streptomyces* antibiotic, which was discovered by H. Umezawa and co-workers of Tokyo. Obtained from a new species *Streptomyces kanamyceticus*, kanamycin is basic and water-soluble, closely related chemically to neomycin and has some features in common with streptomycin; it consists of two amino-sugars linked glucosidally to 2-deoxystreptamine.

In vitro, kanamycin is active against many common pathogenic aerobic Gram-positive and Gram-negative

bacteria and *Mycobacteria*, but some *Pneumococci*, most *Streptococci* and *Pseudomonas* are resistant. Anaerobic organisms, yeasts and fungi nearly all show high resistance. Resistance to kanamycin induced in *Staphylococci* and in *E. coli* is accompanied by complete cross-resistance to neomycin and paromomycin and by partial cross-resistance to streptomycin, but no cross-resistance to unrelated antibiotics. Clinical results show that, given intramuscularly, the drug is effective in staphylococcal infections, gonorrhea, anthrax, and in many infections of the urinary tract, particularly when resistant to other antibiotics. Given orally, it inhibits aerobic intestinal bacteria. Alone, it is of doubtful value in tuberculosis, but is claimed to have some effect with *p*-aminosalicylic acid. The major toxic effects are on the kidney and eighth cranial nerve, but the renal toxicity is less marked than that of neomycin and the adverse vestibular and auditory effects are less than those obtained with streptomycin.

The Royal Institution : Officers

At the annual meeting of the Royal Institution, held on May 1, the following officers were elected: *President*, Lord Brabazon of Tara; *Treasurer*, Mr. W. E. Schall; *Secretary*, Sir Harold Spencer Jones; *Managers*, Dr. T. E. Allibone, Dr. H. D. Anthony, Mr. F. G. Brown, Dr. A. G. Gaydon, Prof. A. Haddow, Mrs. H. K. Hawkes, Dr. H. Heywood, Dr. R. Holroyd, Mr. E. Ironmonger, Prof. L. A. Jordan, Mr. J. Lawrie, Sir Ben Lockspeiser, Mr. J. A. Oriel, Mr. H. P. Rooksby, and Mr. P. H. Schwarzschild; *Visitors*, Mr. A. D. Baynes-Cope, Prof. H. Dingle, Dr. D. H. Follett, Mr. A. J. Haselfoot, Mr. S. Rees Jones, Mr. W. C. Lister, Miss C. M. McDowell, Mrs. J. E. Milton, Mr. F. A. Mitchell, Mr. N. P. W. Moore, Mr. J. D. Peattie, Mr. F. Y. Poynton, Mr. N. Shepherd, Dr. P. C. Spensley, and Dr. N. Stuart.

University News : Birmingham

The Council of the University, subject to the concurrence of the Senate, has gratefully accepted the offer of a contribution of approximately £140,000 spread over seven years for the purpose of enlarging and developing the Graduate School of Highway and Traffic Engineering, and for the establishment of a chair in the subject. The offer is made by a number of bodies concerned with road development, including the motor industry, oil companies, civil and engineering and surfacing contractors, insurance firms and motoring organizations.

The Nuffield Foundation has made a grant of £12,000 to the University, spread over five years from May 1, 1959, towards the cost of an investigation to be carried out in the Research Department of the Institute of Education into the placing, counselling and teaching of part-time students in a local technical college. The research will be under the direction of Mrs. E. C. Venables, at present part-time research fellow in the Institute of Education.

The following have been promoted to senior lectureships from October 1: Dr. J. G. Valatin (mathematical physics), Dr. G. W. Greenlees (physics), Mr. R. H. Knight (physics), Dr. D. H. Whiffen (chemistry), Dr. V. G. Welsby (electrical engineering), Dr. V. Kondic (industrial metallurgy), Mr. P. T. Geach (philosophy), Dr. J. B. Finean (medical biochemistry and pharmacology). The following appointments have also been made: Dr. H. B. van der Raay, to be lecturer in physics; Dr. R. W. Smith, to be lecturer in physical metallurgy; and J. A. Nelder, head of the Statistics Section of the National Vegetable Research Station at Wellesbourne, to be a recognized lecturer in the Department of Pure Mathematics.

London

The following have been appointed to readerships tenable at the Imperial College of Science and Technology: Dr. F. G. H. Blyth (engineering geology); Dr. E. H. Brown (structural analysis); Dr. J. Edelman (enzymology); Dr. S. Eilon (production engineering).

Announcements

Under the statute of the Royal Society which provides for the election of persons who either have rendered conspicuous service to the cause of science or are such that their election would be of signal benefit to the Society, H.M. King Gustaf VI Adolf of Sweden has been elected a Fellow of the Royal Society.

The charter of the Middle East Technical University, Ankara, has been approved by the Grand National Assembly of Turkey. The conception of the University, which is intended to be an international centre of higher learning, was described in *Nature* of February 8, 1958, p. 382.

A symposium, arranged by the International Commission for Optics, in connexion with its fifth congress on Modern Systems for Detecting and Evaluating Optical Radiation, will be held in Stockholm during August 24–30. Further information can be obtained from Prof. E. Ingelstam, International Commission for Optics, Stockholm 70.

The summer meeting of the Science Masters' Association will be held in the Science Laboratories of the Durham Colleges during July 27–31. In addition to the usual programme of meetings and visits, there will be Publishers', Manufacturers' and Members' Exhibitions, and a discussion on "General Trends in Science Teaching in the Universities of the Commonwealth", introduced by Prof. W. B. Fisher. Further details can be obtained from the Meeting Secretary, W. H. Dowland, 93 Westbourne Road, West Hartlepool, Co. Durham.

Under the auspices of the International Union of Biochemistry, a symposium on Hæmatin Enzymes is to be held in Canberra, Australia, during August 31–September 4. The symposium is being arranged by the Australian Academy of Science, and participation is by invitation. The proceedings of the symposium are to be published by the Pergamon Press in a special volume. Further information can be obtained from Prof. R. K. Morton, Department of Agricultural Chemistry, University of Adelaide, South Australia.

An International Conference on Nuclear Structure will be held at Queen's University, Kingston, Ontario, during August 29–September 3, 1960. The conference, in addition to receiving support from the International Union of Pure and Applied Physics, will be sponsored in Canada jointly by Atomic Energy of Canada, Ltd., and Queen's University. The secretary of the conference is Dr. L. G. Elliott, Atomic Energy of Canada, Chalk River, Ontario, to whom further inquiries can be directed.

Erratum. In the article "A New Short-acting Thiobarbiturate", by Dr. M. E. Peel *et al.*, published in *Nature* of May 23, p. 1443, in Table 1 for compound B.137, R' should read Bu^s, not Bu^i.

DEPARTMENT OF HUMAN ANATOMY, OXFORD: NEW BUILDINGS

THE time devoted by medical students to the meticulous dissection of cadavers and the memorizing of a mass of anatomical detail has diminished considerably in Great Britain during the past half-century. It is now recognized that an encyclopædic knowledge of topographical anatomy is devoid of educational value and its practical application is restricted to surgical specialists and a few selected research workers. By contrast, a knowledge of the structure and functional role of the tissues which go to make up the body in subjects of all ages, of their reactions to stress, and to the wear and tear of everyday life, is acknowledged to be of both educational and practical value to physicians, surgeons, general practitioners and research workers alike.

This re-orientation in the role of anatomy as an academic discipline in Britain owes more to Sir Wilfrid le Gros Clark than to any other anatomist. F. P. Mall pioneered a similar movement at Johns Hopkins University in the United States of America in the early 1900's which was quickly accepted and exploited by such eminent scientists as George Corner, Herbert Evans and George Wislocki. Now, however, there is a tendency in the United States to regard anatomy as a part of biology almost divorced from medicine, and to appoint more and more teachers who have not had a medical training. The opening of the new Department of Anatomy in the University of Oxford (Fig. 1) is a milestone in the history of a reformation in England which has proceeded more slowly and which seeks to avoid this tendency.

Sir Wilfrid's genius has been to gather around him, and provide facilities for, people interested primarily in the changes which occur in the tissues of the human body in health and in response to trauma (and selected diseases) from conception to death from old age. This is not to say that experimental work on lower animals is not carried out in his Department; indeed, it is, but that, under his leadership, teaching and research are directed more towards the biology of man than of other animals. Sir Wilfrid has contrived to allow anatomy to evolve rather than denying it a place as an academic discipline or allowing it to become a home of lost biological causes. This he has achieved through his unique distinction both as an outstanding experimental neurologist and as an outstanding authority on primate anthropology which, incidentally, he regards as a hobby.

The subjects most strongly represented in the new Department are neuroanatomy, with special reference to vision, olfaction and common sensation. Modern methods of microscopy, including electron, reflecting, phase contrast and interference techniques, are also

Fig. 1. New Department of Human Anatomy, Oxford

under active investigation. They are housed in special rooms in the basement of the building and are being used, among other things, to obtain quantitative data concerning the anatomy of individual living cells. The mechanics of muscular activity in man and in experimental animals are also being studied by a number of different methods, including strain gauge techniques and electromyography. Physical anthropology is also strongly represented and intensive work is being carried out on the adaptation of human subjects of different age and race to extremes of environmental temperature.

The old department has been entirely transformed from a mushroom growth of ill-suited, over-crowded research rooms, leading off from an old-fashioned dissecting room and a small museum, to a modern research laboratory adaptable to any field of biological study.

The essential features of the new Department are an extremely well lit, adequately ventilated and conveniently proportioned dissecting room. This can also be used for the study of surface and functional anatomy. It surmounts a large, well-equipped histological laboratory which in turn surmounts a basement containing an up-to-date embalming room, body store, and a room in which recently deceased persons can be viewed by relatives should the necessity arise. Close to this unit are a conventional lecture theatre, a small demonstration theatre and a departmental library. Beyond these is a commodious museum which can also be used as a study and reading room. This has evolved from the former dissecting room by a process of adaptation and the skilful use of modern methods to improve the interior décor of the old structure. Lying between the museum and the new dissecting room are the laboratories and offices occupied by the staff.

The staff includes a professor, two readers and four University demonstrators, each of whom devotes his time to a particular branch of anatomy, assisted by departmental demonstrators and postgraduate students reading for higher degrees. A few rooms which serve as combined laboratories and offices have been set aside for the use of temporary visitors from overseas. Housed and integrated with the rest of the Department is a Medical Research Council climatic and working efficiency unit which possesses an up-to-date climatic chamber. The Department also has a large well-equipped workshop for handling metal, plastics and wood, as well as a smaller instrument workshop. It also contains a large well-designed photographic department containing the most modern equipment which is capable of handling every kind of photographic problem. The animal house and operating theatre are on the roof of the building and conform to the highest modern standards. The individual research laboratories are simple yet quickly adaptable to different kinds of biological research with the minimum of expense. In particular, they are well lit and ventilated, and provided with a service panel encircling the room, having gas, electrical (direct and alternating current) and compressed-air outlets at intervals. The rooms are also provided with sinks having hot and cold water supplies. Three of the rooms contain, in addition, fume cupboards, and two rooms have voltage-stabilized alternating-current electrical outlets and dark-room blackout blinds. There is also a small light- and sound-proof room. The majority of the benches in these rooms

Fig. 2. Bust by Sir Jacob Epstein of Sir Wilfrid le Gros Clark

are movable but strong, rigid, relatively light and fitted with plastic tops. They have been supplied in two standard heights, lengths and widths, and they can be fitted adjacent to the walls beneath the service panel. They can thus be moved from room to room according to requirements. A variety of units in two sizes containing drawers and/or cupboards have been provided for fitting beneath the benches. These can also be moved from room to room to suit particular requirements. These research rooms can therefore be adapted to serve such diverse techniques as standard histology, tissue culture, biochemistry and biophysics. An adequate number of lavatories, wash basins, locker and store rooms have also been provided.

Sir Wilfrid's friends and colleagues have recognized that his genius has set him among the immortals. But as the regius professor of medicine at Oxford, Sir George Pickering, said when he opened the new building on March 16: "Immortality as is commonly conceived is relative rather than absolute and, since what is generously called the growth of scientific literature, may obscure masterpieces like le Gros Clark's writing, his friends thought it right to secure his more permanent immortality by asking Sir Jacob Epstein to create a portrait bust". The opening of the new Department comes just twenty-five years after Sir Wilfrid was appointed Dr. Lee's professor of anatomy and Fellow of Hertford College in the University of Oxford. It is therefore very fitting that a work of this kind should have been commissioned from a great sculptor in honour of Sir Wilfrid, to be permanently housed in the Department which his vision has done so much to create.

The bronze portrait bust of Sir Wilfrid le Gros Clark is sited in the entrance hall of the new building in a quiet and dignified setting but where it can be seen and examined for the work of art which it is (Fig. 2).

G. WEDDELL

U.S. NATIONAL ACADEMY OF SCIENCES

Centennial Gift from the Equitable Life Assurance Society

THE U.S. National Academy of Sciences, the president of which is Dr. Detlev Bronk, is to receive a gift of a million dollars from the Equitable Life Assurance Society of the United States as a contribution to the nation's welfare during the Society's hundredth anniversary. The Academy itself celebrates its centennial in 1963.

The gift will provide for the erection of a Hall of the Life Sciences, in which will be housed the many scientific activities of the Academy and its National Research Council in the fields of biology and medicine.

The National Academy of Sciences is a private, non-profit organization electing its own members from among leading scientists of the United States. The Academy was established in 1863, under a Congressional Charter signed by President Lincoln, to advance science, further human welfare and advise the Federal Government on scientific and technical matters.

The National Research Council was organized by the Academy in 1916 at the request of President Woodrow Wilson, as a part of the Academy, in order to enable representatives of the major scientific and technical societies to co-operate in the efforts of the Academy in the service of science and the national welfare.

The Academy–Research Council is the principal agency through which American scientists participate in co-operative international scientific undertakings such as the International Geophysical Year and other activities of the international scientific unions.

The present building of the National Academy–Research Council, which is generally considered to be one of the most beautiful in Washington, was constructed in 1924 with funds provided by the Carnegie Corporation of New York and was dedicated thirty-five years ago by President Coolidge. It is situated on Constitution Avenue, adjacent to the New State Department Building now under construction, and facing the memorial to Abraham Lincoln, who was the founder of the Academy.

Architects for the new Hall will be Harrison and Abramovitz, who have been associated with the design of many of the notable buildings of America, such as the Rockefeller Center, the Lincoln Square project in New York, and the United Nations building.

Dr. Bronk made the following comment on the Equitable gift: "Erection of this new Hall of the Academy to house the medical and life sciences will be of great value to our nation. It is eminently appropriate that the Equitable Life Assurance Society thus contribute to the work of the Academy, for we are both private organizations devoted to the public welfare.

"Both organizations are deeply concerned with the furtherance of those sciences which prolong life and increase health. We are both national in scope. In the beautiful centre of our national capital, the Hall of the building provided by the Equitable centennial gift will symbolize your service to the welfare of the people of our nation and will enable us to increase our service as we, too, begin our second century".

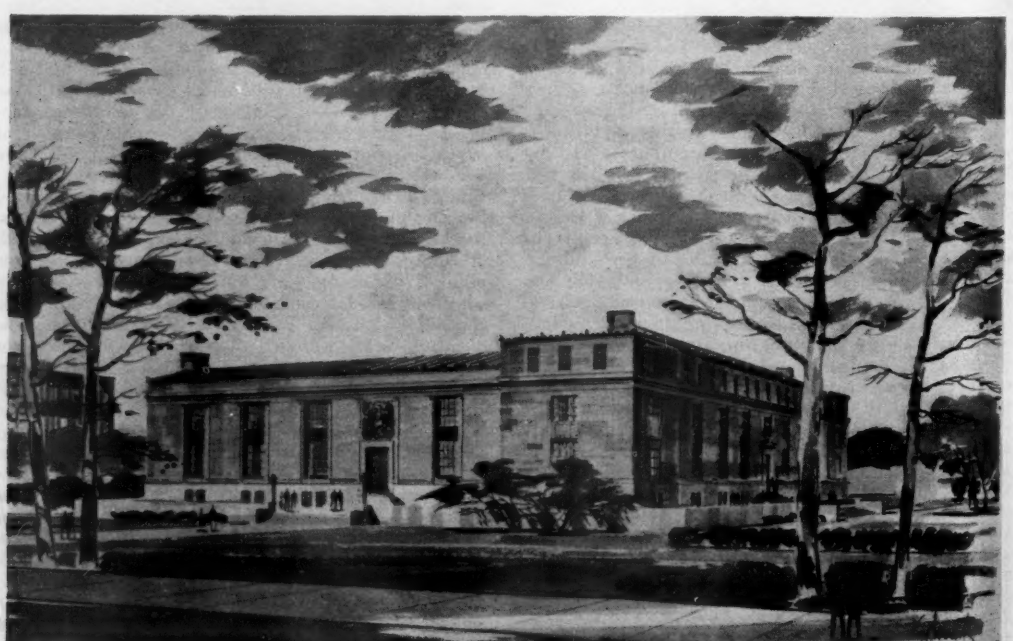

Fig. 1. Architect's drawing of the proposed Hall of the Life Sciences, U.S. National Academy of Sciences, provided by the Equitable Life Assurance Society

When the Academy's building was erected in 1924, it was planned to accommodate additional wings as the need developed and funds became available. With the greatly increased scope of the Academy's work, more space has been urgently needed, and many activities of the Academy–Research Council have had to be housed in widely scattered locations throughout Washington.

The work of the Academy–Research Council is carried on by more than a thousand committees comprising scientists who voluntarily give their time and represent all fields of science; they are served by a full-time staff of more than 1,100. More than 10,000,000 dollars a year is provided for the work of the Academy by private foundations, contracts and grants from the Federal Government, and income from the Academy endowment of approximately 7,000,000 dollars a year.

Elections

Dr. Hugh L. Dryden, deputy administrator of the National Aeronautics and Space Administration, has been elected to a second four-year term as home secretary of the U.S. National Academy of Sciences.

Dr. Roger Adams, research professor of chemistry, University of Illinois, and Dr. William V. Houston, president of Rice Institute, have been elected members of the Council. The two councillors who are retiring are Dr. I. I. Rabi, professor of physics, Columbia University, and Dr. F. E. Terman, professor of electric engineering, Stanford University.

As members of the Council of the Academy, the home secretary and the two new councillors will share responsibility for the general conduct of the Academy and its National Research Council.

The following have been elected to membership of the Academy:

Dr. Philip H. Abelson, director of the Geophysical Laboratory, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

Prof. Walker Bleakney, Brackett research professor in Princeton University.

Prof. David Bonner, professor of microbiology, Yale University.

Prof. Tom Bonner, professor of physics, Rice Institute.

Dr. Walter Brattain, research physicist, Bell Telephone Laboratories (on leave with the National Defense Research Committee, Columbia University).

Prof. Leo Brewer, professor of chemistry, University of California at Berkeley.

Prof. Frank Brink, dean of graduate studies, Rockefeller Institute.

Prof. Jens C. Clausen, Division of Plant Biology, Carnegie Institution of Washington, and professor of biology, Stanford University.

Prof. Samuel Eilenberg, professor of mathematics, Columbia University.

Prof. John D. Ferry, professor of chemistry, University of Wisconsin.

Prof. Kurt O. Friedrichs, professor of applied mathematics, New York University.

Prof. Hiram B. Glass, professor of biology, Johns Hopkins University.

Prof. M. J. Herskovits, professor of anthropology, Northwestern University; former visiting professor, Graduate School, University of Illinois.

Prof. Herman M. Kalckar, professor of biochemistry, Johns Hopkins University.

Prof. Konrad B. Krauskopf, professor of geology, Stanford University, and geologist, U.S. Geological Survey.

Prof. I. Michael Lerner, professor of genetics, University of California at Berkeley.

Dr. Rudolph L. B. Minkowski, Mount Wilson and Palomar Observatories, and research associate, California Institute of Technology.

Dr. Harry F. Olson, Radio Corporation of America Laboratories.

Prof. C. Pfaffmann, professor of psychology, Brown University.

Prof. Richard J. Russell, professor of physical geography, and dean of the Graduate School, Louisiana State University.

Prof. John A. Simpson, scientific consultant, Argonne National Laboratory.

Prof. Dean S. Tarbell, professor of organic chemistry, University of Rochester.

Prof. Henry Taube, professor of chemistry, University of Chicago.

Prof. James A. Van Allen, professor of physics, State University of Iowa.

Prof. Cecil J. Watson, professor of medicine, University of Minnesota.

Prof. Gregor Wentzel, professor of physics, University of Chicago.

Prof. Fred L. Whipple, director, Smithsonian Astrophysical Observatory (a close associate with Harvard College Observatory).

Prof. William B. Wood, jun., vice-president of medical affairs, and professor-elect of microbiology, Johns Hopkins University.

Prof. Clarence M. Zener, director, Westinghouse Research Laboratories.

Dr. Raymond E. Zirkle, professor of radiobiology, University of Chicago.

CHARACTERISTICS OF THE ANTARCTIC ICE-SHEET

THE Royal Astronomical Society Geophysical Discussion of February 27 was held jointly, in the Society's rooms at Burlington House, with the British Glaciological Society. This combining of interests by the two organizations was matched by the bringing together of the theoretical with the directly practical interests, for the main speakers were Dr. J. F. Nye (chairman) on one hand, and M. B. Imbert, Mr. J. G. D. Pratt and Dr. H. Lister on the other. Dr. Nye's important contributions to the study of ice-sheets are well known and, perhaps more than anyone, he has shown clearly what physical properties should be measured by the expeditions that go to make the necessarily difficult and sometimes hazardous experiments; and he has put together the numbers of the problem so that the field men can plan their experiments and know when they are getting a reasonable answer.

M. Imbert has for many years been principal assistant to Dr. Paul Emile Victor of the Expéditions

Polaires Françaises, and Mr. Pratt is a seismologist of world-wide experience in the British Petroleum organization. They both had returned recently from Antarctica and were able to describe some of their results, both seismic and gravitational, fresh from the detailed analysis that awaited their return home. As opposed to the static problem of what is there now, Dr. Lister studies the mechanism of deposition of snow and its formation into an ice-sheet, together with the dynamical aspects and the history of these phenomena. Dr. Lister and Mr. Pratt were members of Sir Vivian Fuchs's Commonwealth Trans-Antarctic Expedition, and M. Imbert was leader of the French team in Antarctica for the International Geophysical Year.

Dr. Nye explained that the behaviour of an ice-sheet is governed by two opposing forces : the weight, which tends to squeeze the ice out sideways, and the resistance to outward flow provided by the bed. These two forces are essentially in balance.

The properties of the ice depend upon the temperature distribution in the ice, and this in turn is affected by two main sources of heat. Heat is flowing from the Earth itself, presumably in the absence of volcanic activity, at the normal rate, and it is also developed by friction as the ice moves over the rock bed. If the effects of transverse convection are ignored, theory suggests that both sources of heat are tending to make the lower layers of ice warmer than the upper ones. The ice will therefore become more plastic at the bottom than at the top. The shear stress tending to move the mass of ice is known to increase linearly with depth in the ice, and therefore the shear distortion will take place predominantly in the lowest layers. It does not matter very much if, in the analysis, the distortion is regarded as slipping on the rock bed rather than very intense shear in the lowest layer.

The movement of the ice-sheet is outwards towards the unconstrained perimeter, and the calculated strain rates at the ice – rock interface are of the order of about 10^{-3} per annum. This is much higher than the slow rate (about 10^{-4} per annum) of the squeezing down movement of vertical compaction, which is partly or entirely compensated by the addition of new material by snowfall. However, it is the weight of accumulated snow that ultimately provides the driving force for the ice-sheet, and the connexion between the vertical and the outward strains in the ice is such that, in a steady state, the outflow is just sufficient to balance the accumulation.

A simple model of the ice-sheet shows that the steady-state thickness of the ice is proportional only to the fifth or sixth root of the accumulation. This means that the height of the ice-sheet is very insensitive to even long-period changes of accumulation, and it is for this reason that calculations of the equilibrium form of an ice-sheet can be made with fair accuracy without a knowledge of the accumulation. The relevant measurements that are required, therefore, from the field experiments are a knowledge of the topography, the thickness of the ice, and the past and present rates of accumulation.

M. Imbert's results covered a traverse, 300 miles long, running inland from the French International Geophysical Year base in Adelie Land. In the 1957–58 season seventy-five shots were fired to obtain seismic reflexion results at twenty-five stations. The recording gear covered the nominal frequency-range of 600 c./s., but as with most Arctic and Antarctic seismic investigations it was found desirable to put the charge as deep as possible into the layers of poorly compacted snow. A charge of 1 kgm. of high explosive at a depth of 18 m. was found to give readable reflexions, and the quality of a number of 'typical records' that were shown were certainly excellent. Mr. Pratt managed to bury some of his charges to a depth of 12 m., but this was not really deep enough, and in many cases lack of time forced him to be content with surface shots. It is noticeable that the reflexions do not stand out so clearly as some of M. Imbert's, but care must be taken in ascribing record quality entirely to the effect of depth of charge, since some results from the British North Greenland Expedition show that unexplained phenomena deep down in the ice also have considerable effect on the strength of reflexions.

The French seismic profile was supplemented in 1958–59 by seventy gravity stations, and the topography of the surface of the ice-sheet was measured to an accuracy estimated at 15–20 m. Barometric heights were backed up by estimates of atmospheric pressure obtained from radiosonde measurements. The mean height of bedrock was 40 m. below sea-level along the traverse, but elevations and depressions of several hundred metres were observed about this mean. If h km. is the height of the surface above sea-level at point x km. inland, then the surface of the ice fitted the ellipse :

$$\left(\frac{h}{2{\cdot}68}\right)^2 + \left(\frac{550 - x}{550}\right)^2 = 1$$

with a root-mean-square error of $\pm$ 25 m.

The profile presented by Mr. Pratt covered the 2,000-mile course of the Commonwealth Trans-Antarctic Expedition. The seismic picture was different from that of other observers in that the ice – rock interface was, except for two troughs on the Weddell Sea side of the South Pole, well above (about 1,500 m.) sea-level. This may be accounted for on the Ross Sea side of the pole by the fact that the course of the expedition lay over the foothills of a known mountain range.

The gravity measurements were checked at the South Pole and at the Ross Sea, but the uncertainty about height in between gives a possible error of 25–50 mgal. The estimated error due to drift is much less than this, of the order of 5 mgal. The gravity results support the seismic picture, and Bouguer anomalies have been drawn assuming the profile found from the seismic measurements, together with a rock density of 2·1 gm./cm.^{3}. There is a large anomaly of – 200 mgal. which cannot be explained away by the uncertainties of the measurements. It appears that the ice-sheet must have been subject to a much greater loading in the past than is effective to-day, and that the Antarctic land mass is, like Scandinavia, tending to rise. It would be most interesting to make a careful series of elevation measurements, but the technical difficulties of such observations from a continent fringed with ice are considerable.

A single American seismic result at the South Pole differed from the several that Pratt obtained in the vicinity of the pole, and this was explained by the inherent difficulty of interpreting an isolated record taken under the difficult conditions pertaining to ice-sheets. Pratt had gained a great deal of experience by the time the pole was reached, and the polar observation was a continuation of a whole series of

reflexions on the profile hundreds of miles long, so that, apart from the fact that several independent results were obtained, Pratt's value must be accepted rather than the much deeper American figure.

A short refraction line at the South Ice station, 300 miles inland from the main Shackleton base, showed that the velocity in the 80–90 metre thick surface layer varied from 0·5 to 3·96 km./sec., in agreement with observations in other parts of the world. An interesting point emerged from the refraction results. The line ran over undulating snow, but there was no sign on the record of the surface variations in height. It must be assumed, therefore, that the troughs of the undulations consist of lower-velocity material than do the humps. Some shots fired on the ice-shelf yielded reflexions from the sea bed, but not from the bottom of the ice. This is a familiar experience with Antarctica geophysicists, but Pratt has pointed out that a unique solution of ice thickness can be obtained from the travel time of waves reflected from the sea-bed.

Dr. Lister's simple method of following the accumulation of snow by laying down strings at fortnightly intervals and afterwards checking their profile by digging was supplemented by counting the years indicated in the stratification caused by seasonal changes in climate. Pits and drilled cores at South Ice enabled Lister to look back to the year 1895, and across the continent twenty bore-holes reached back twenty years and sixty more were deep enough to include the deposition of the past five years. Along the central portion of the traverse followed by the Trans-Antarctic Expedition the deposition-rate was found to be fairly constant at 8–9 cm. water equivalent a year. This is rather higher than the 6 cm. found by the American observers at their South Pole Base, but may be accounted for by the fact that much of the expedition's route followed a trough in the surface topography. The accumulation increases to about 25 cm. water equivalent at the edges of Antarctica, and Lister calculates a deposition-rate of 13·1 gm./cm.^{2}/year as an average over the whole continent. The wastage is assessed at 10·1 gm./cm.^{2}/year mainly made up of 5·0 melting, 4·0 icebergs, 1·0 evaporation and 0·1 deflation. It appears then, from the present-day observations, that there is a net gain of ice, a result (ignoring any time-lag) opposite to that indicated by the negative gravity anomaly. During the discussion it became apparent that the figures for melting and for loss by breaking off of ice-floes might be changed in the light of other observations, but in any event the present material balance was one that applied to decades rather than to the thousands of years (at least) during which changes in the ice-cap, sufficient to account for the gravity results, would be expected to take place.

Some of Lister's observations made it clear that precipitation favoured hollows rather than the crests of undulations, and that there was a migration of the crests with time. Nye raised the question of whether the presence of the undulations might affect the travel of the whole sheet, because their presence implies a big change of slope over a distance larger than the thickness of the sheet. There was clearly a mechanism here which could give local fluctuations of velocity and hence it would be very difficult to make sense of any isolated measurements of ice-sheet velocity. It is possible that the movement of the crests is only apparent, and is caused by the erosion of hard wind-blown snow at the crests of the undulations, with a simultaneous build-up of a new crest above the snow-filled troughs. Whether they are caused by aerodynamic or by hydrodynamic means, the undulations and sastrugi deserve further attention, and the results that have been collected recently should call forth a new advance on the theoretical side.

T. F. Gaskell

THE NATIONAL SCIENCE FOUNDATION

REPORT FOR 1957–58

More than half the eighth annual report of the National Science Foundation for the year ended June 30, 1958*, is occupied by appendixes listing the membership and staff of the Board, its committees and advisory panels, grants for basic research, fellowship awards, publications of the Foundation and others resulting from research grants and fellowships. The latter now runs to some 1,315 items, compared with 850 in 1956–57, and is arranged according to the several divisions of the Foundation. Fellowship awards during the year totalled 1,527, amounting to about 5·6 million dollars in value. Of these, 408 were in the biological sciences, 314 in physics and astronomy, 306 in chemistry, 206 in mathematical sciences, and 193 in engineering. Of the total, 1,084 were predoctoral, 227 postdoctoral and 216 in the science faculty programme for improving the quality of science teaching. Grants for research amounted to more than 19 million dollars, and of these 1,120 grants, 605, totalling 8,881,130 dollars, were in biological and medical sciences; 466 grants, totalling 9,507,825 dollars, in mathematical, physical and engineering sciences; and 49 grants, totalling 725,950 dollars, in social science. During the year, 190 scientists received grants, totalling 113,220 dollars, in support of travel to international scientific meetings, and the Foundation sponsored and provided partial support for thirty-four scientific conferences and symposia.

Reviewing the support given to basic research in the sciences, in the Division of Biological and Medical Sciences, the report stresses the clue to the control of tuberculosis provided by the study of the honey guide, a wax-eating bird found primarily in Africa, from the intestinal tract of which a wax-splitting bacterium was isolated that contains a protein which inhibits the growth of the tubercle bacillus in tissue cultures. Doubts have been thrown on the basic genetic axiom regarding the individuality of genes by the discovery that the gene in corn which produces colour in the kernel can be permanently modified by bringing it into combination with a particular partner gene. Results have been obtained suggesting that some plants may operate as a well-knit group or unit having a common physiology, and it has also been found that nerve growth factors similar to the tumour factors are present in the

* National Science Foundation. Eighth Annual Report for the Fiscal Year ended June 30, 1958. Pp. xv+246 (8 plates). (Washington, D.C.: Government Printing Office, 1959.) 1 dollar.

salivary glands of the mouse and rat, in snake venoms and in the venom of the Gila monster. Sex hormones have been found to control growth in the more primitive plants such as water moulds and ferns, and protein-like material has been produced by application of heat (170° C.) to mixtures of amino-acids. The discovery of a method for introducing sulphydryl and disulphide groups into proteins and protein-like molecules has permitted the physical, chemical and physiological characteristics of proteins to be altered at will. Deoxyribonucleic acid has been synthesized by adding an enzyme obtained from bacteria to a previously prepared mixture of nucleic acids, and in studies of the growth of *Brucella abortus* and *Diplococcus pneumoniae* addition of a mixture of bacterial deoxyribonucleic acid and deoxyribonuclease to growing cultures of these organisms had striking effects upon the selective establishment of virulent cells in an initially non-virulent population.

In the Division of Mathematical, Physical and Engineering Sciences, the report directs attention to the cloud-seeding experiments near Tucson, Arizona, where radar observations indicated that precipitation from larger seeded clouds was greater than from similar unseeded ones; to the development of a neurological instrument which enables ultrasonic waves to be used to cut out tiny regions of the inner brain without disturbing the inner structure; to a laboratory model of a stream which, used in conjunction with a high-speed motion-picture camera, has clarified the motion of individual sand grains in a flowing stream; to the laboratory confirmation of the hypothesis that pegmatites are relatively dry melts (magmas) and are closed physico-chemical systems, and that the giant crystals are formed during a 'second boiling'; to the development of techniques whereby free radicals are formed and immediately trapped on cold surfaces (− 424° F.); to the measurement of variations in the pull of gravity in Utah and Eastern Nevada which have permitted charting the major contours of the buried bedrock and given important clues to the configuration of the fault blocks and other structural patterns; and to the total stereospecific synthesis of several antibiotics and the production of a substance identical with natural rubber in physical characteristics by careful control of the spatial relations of the groups in the molecule.

In the Social Science Research Programme, electronic computers have been used to determine more quickly and sensitively the stages of the business cycle and to separate significant trends from temporary irregularities.

Besides the surveys made by the Foundation of the research and development effort of the United States and a brief report on the Conference on Research and Development and its Impact on the Economy called by the Foundation for May 20, 1958, the report summarizes the Foundation's activities in the International Geophysical Year. Apart from the fellowship programme already noted, the report deals at some length with the work which the Foundation is doing to improve science education. For this purpose the Foundation received a supplemental appropriation of 9 million dollars, which was used for the award of additional fellowships and to assist the attendance of more high-school science teachers at the summer institutes, of which 126 were held in 1958 in forty-seven States and three Territories. For 1959 the appropriation for the Foundation's educational programmes was increased to about 60 million dollars, but the educational implications of the report are discussed separately.

ENERGETIC COUPLING IN THE RESPIRATORY CHAIN

By Dr. POUL E. GLAHN and Dr. SIGURD O. NIELSEN
Carlsberg Laboratory, Copenhagen

THE important part played by the energetic coupling between substrate oxidation and adenosine triphosphate (ATP) synthesis (oxidative phosphorylation) in the energy economy of animal cells is well known[1]. The demonstration, *in vitro*, of energetic coupling between oxidation and reduction of carriers in the respiratory chain and adenosine triphosphate synthesis at present requires particulate preparations containing either mitochondria or multifunctional mitochondrial fragments. Experiments with such preparations indicate that the oxidation of reduced diphosphopyridine nucleotide (DPNH) by ferricytochrome *c* is coupled to the synthesis from adenosine diphosphate and free orthophosphate (P_i) of two moles of adenosine triphosphate per mole of reduced diphosphopyridine nucleotide oxidized[2,3] and that the oxidation of ferrocytochrome *c* by molecular oxygen is coupled to the synthesis of at least one mole of adenosine triphosphate (two moles being energetically possible) per two electrons transferred[3,4,14]. The detailed mechanism of this energetic coupling in the respiratory chain is essentially unknown in contrast to the coupling at substrate level[5] and its elucidation constitutes a major problem of contemporary biochemistry. In view of this fact and the great difficulty of experimental work with multifunctional, highly organized, and relatively ill-defined particles, it is amazing that no more speculation has appeared in the literature concerning the chemical nature of the coupling reactions, in particular the primary ones involving oxidation-reduction of respiratory carriers. It would appear that 'educated guesses' at the possible organic chemistry of these primary coupling reactions involving known or hypothetical respiratory carriers might be useful in the planning of new experimental approaches. The present article presents some ideas on the primary coupling reactions at all three phosphorylating sites between oxygen and reduced diphosphopyridine nucleotide. We feel less hesitant about publishing these views, which may eventually turn out to be wrong, because it has been possible to consider the primary coupling reactions at all four phosphorylating sites, including those at the cytochrome a_3- and substrate-levels, from a unified point of view.

The total number and location of carriers in the respiratory chain are still unknown, although it is generally agreed that diphosphopyridine nucleotide

(DPN), flavine adenine dinucleotide (FAD), cytochromes *c*, *a*, and a_3 are in the chain in the order given[6]. Tentative coupling schemes based on these established carriers have been proposed; for example, the reaction:

$$\text{DPNH} + X + \text{FAD} \rightarrow \text{DPN} \sim X + \text{FADH}$$

has been suggested[1] as the primary reaction for the phosphorylation site in question. The whereabouts of the point of attachment of X to the nucleotide in the energy-rich compound DPN $\sim X$ is, however, left open.

Recently the organic chemistry of the coupling reactions has received some attention. Harrison[7] and Todd and co-workers[8] have suggested the phosphorylated form of a hypothetical, hydroquinone-type respiratory carrier as an intermediate which afterwards transfers its phosphate group to adenosine diphosphate following oxidation to the quinone-level. Similarly, Lindberg and co-workers[9] have postulated phosphorylation in the 2-position of the reduced *iso*alloxazine ring of reduced flavine adenine dinucleotide. Upon oxidation the phosphate group is transferred to adenosine diphosphate. In the case of hydroquinone phosphate experimental evidence is available that the phosphate group may actually be transferred to adenosine diphosphate after oxidation[8]. These examples bring out the essence of the coupling problem. When oxidized carrier A oxidizes reduced carrier B with the coupled synthesis of adenosine triphosphate, A_{ox} reacts directly with B_{red} only after combination of one or other of them with a group X (not necessarily phosphate) forming a 'low-energy' bond (standard free energy of hydrolysis $\Delta F^0 \simeq 0$). Upon reduction of A_{ox}—X by B_{red} or oxidation of B_{red}—X by A_{ox} the energy-rich compounds ($\Delta F^0 < -8$ kcal./mole)[10] $A_{red} \sim X$ and $B_{ox} \sim X$, respectively, are formed. In terms of standard oxidation potentials, E^0, this means that E^0 for the couple A_{ox}—$X/A_{red} \sim X$ is decreased by more than $8{,}000/96{,}500 \times z \times 0{\cdot}24$ V. compared with E^0 for the couple A_{ox}/A_{red}. This corresponds to 0·35 V. for a one-electron process ($z = 1$) and 0·17 V. for a two-electron process ($z = 2$). Similarly, E^0 for the couple $B_{ox} \sim X/B_{red}$—X is increased by more than 0·35 V. for a one-electron process and 0·17 V. for a two-electron process compared with E^0 for the couple B_{ox}/B_{red}.

We shall now show how reduced diphosphopyridine nucleotide, reduced flavine adenine dinucleotide and ferricytochrome a_3 may combine through low-energy linkage with a nucleophilic group X^- (RS^-, $RCOO^-$, $H_2PO^-_4$, etc.) in such a way that the compounds DPN $\sim X$, FAD $\sim X$, and (Fe(II) cyt-a_3) $\sim X$ are energy-rich. The coupling schemes shown in Fig. 1 include the primary coupling reaction at substrate level[5] for comparison.

To see how these reaction schemes for diphosphopyridine nucleotide and flavine adenine dinucleotide transform the bond between X and the respiratory carrier from a low-energy bond on the left to an energy-rich bond on the right, the main bond systems in which resonance stabilization occurs are indicated in the formulæ (Fig. 1). Without going into details (for example, ref. 11) we may state that it follows from the uncertainty principle that the energy due to resonance of the molecule falls roughly as $n^{-\frac{1}{2}}$, where n is the number of bonds involved in a resonating bond system that resonates between structures of comparable energy. It follows that removing the amide carbonyl group of reduced diphosphopyridine

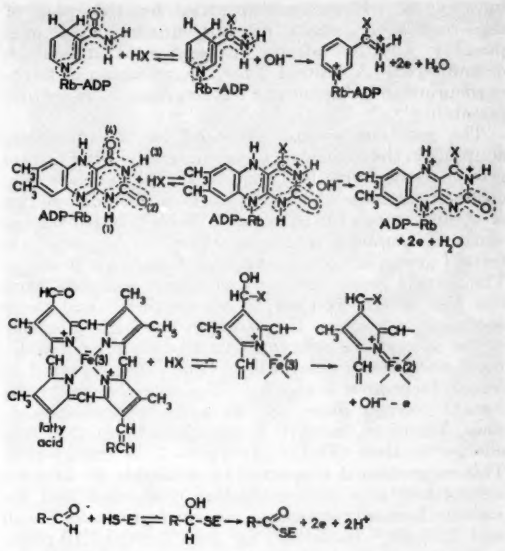

Fig. 1

nucleotide or the 4-carbonyl group of reduced flavine adenine dinucleotide from the resonating five-bond system to which it belongs (similar in both compounds) by substituting X for O occurs at the expense of only a small loss in resonance stabilization energy, because the molecules are still able to resonate over the four remaining bonds indicated in the formulæ. On the other hand, if the nucleotides are in the oxidized forms, and the same carbonyl groups are removed by substituting X for O, this occurs with a considerable loss in resonance stabilization energy which amounts to almost the whole of that of the amide group. The DPN $\sim X$ and FAD $\sim X$ bonds may, therefore, be considered as energy-rich. This conclusion is supported by a comparison of the standard oxidation potentials E^0 for the couples DPN/DPNH and acetyl-DPN/acetyl-DPNH (in the latter a methyl group is substituted for the nicotinamide amino-group). E^0 for acetyl-DPN is 0·072 V. higher than E^0 for DPN (ref. 12). The resonance stabilization energy in acetyl-DPNH is smaller than in DPNH — X because resonance in the former but not in the latter involves a charge separation; it is therefore reasonable to suppose that E^0 for the couple DPN $\sim X$/DPNH — X might be at least 0·17 V. higher than that of the couple DPN/DPNH.

It will be noticed that in the reaction schemes above it is the 4-position which combines with X, whereas Lindberg and co-workers[9] suggested the 2-position as the point of attachment. On the basis of considerations of resonance energy, like those above, the 2-position, however, appears to be less suited than the 4-position for engaging in the primary coupling reaction.

The number of electrons transferred in the energetic coupling reaction in the part of the respiratory chain between cytochrome *c* and oxygen is unknown[13]. A two-electron reaction involves either a higher oxidation state than ferricytochrome or a strong interaction between two cytochrome prosthetic groups, neither of which has been demonstrated. A one-electron coupling reaction might imply a maximal P/O ratio of 2 for the oxidation of ferrocytochrome *c*

by oxygen. Experimental ratios for this part of the respiratory chain are all smaller than one, possibly because of the experimental difficulties encountered. A ratio of 2 for the oxidation of ferrocytochrome *c* by molecular oxygen remains a definite possibility[14].

The reaction scheme proposed for the energetic coupling in the cytochrome system involves the formyl group of porphyrin *a* of cytochrome a_3 and is a one-electron process. The porphyrin *a* formula shown is the one given by Dixon and Webb[15], based on the work of Lemberg and co-workers[16]. A porphyrin formyl group is not present in cytochromes *b* and *c*. The formyl group tends to withdraw electrons from the rest of the iron-porphyrin complex[17] and there are various reasons, for example the high intensity of the α-band, for believing that there is much double-bond character in the iron-pyrrole nitrogen bond in ferrocytochromes *a* and a_3. The replacement of the formyl oxygen atom by *X* in ferrocytochrome a_3 may, therefore, involve a considerable gain in free energy so that (Fe(II) cyt–a_3) $\sim X$ is energy-rich. This suggestion is supported by available E^0 data for substituted iron phenanthroline complexes and for various hæmochromogens. In sulphuric acid Smith and Richter[18] found E^0 for iron 5-nitro-1,10-phenanthroline to be 1·25 V. compared with 1·06 V. for the unsubstituted iron 1,10-phenanthroline. At 30° C. and *p*H 9·63 the following E^0 values have been reported[19]: for the dicyanide hæmochromogens of coproporphyrin (all side-groups saturated) − 0·247 V., and of sphirographis porphyrin (a formyl and a vinyl side-group) − 0·113 V. The introduction of the electron-withdrawing groups NO_2 and CHO into the phenanthroline and porphyrin molecules increases the E^0 value for the iron complexes. The increase is less than the required 0·35 V. for a one-electron process, but this may tentatively be ascribed to the difference between porphyrins and other iron ligands in dicyanide sphirographis hæmochromogen, dicyanide coproporphyrin hæmochromogen, and cytochrome a_3.

Although porphyrin *a* is the prosthetic group of both cytochromes *a* and a_3 we prefer to write the primary coupling reaction with cytochrome a_3, because the E^0 span between cytochromes *c* and *a* is only 0·03 V., that is, too small for a coupled phosphorylation to occur[1]. The one-electron coupling reaction proposed is compatible with an overall P/O ratio of 1 for the oxidation of ferrocytochrome *c* by oxygen if molecular oxygen or hydrogen peroxide is reduced by one mole each of cytochrome *a* and cytochrome a_3 in a two-electron process.

The three primary coupling reactions proposed are analogous to the primary coupling reaction at substrate-level in so far as they involve a low-energy substitution at a carbonyl group and a gain in resonance stabilization energy on hydrolysis of the energy-rich form. The transfer of bond energy from $A_{red} \sim X$ or $B_{ox} \sim X$ to adenosine triphosphate may, therefore, also take place by analogous or similar mechanisms at all three phosphorylation sites in the respiratory chain. The suggested involvement of the oxidized forms of diphosphopyridine nucleotide and flavine adenine dinucleotide in energy-rich linkages is in agreement with labelled phosphate and adenosine triphosphate exchange experiments[3,20].

We are happy to acknowledge the interest and kind advice of Prof. K. Linderstrøm-Lang.

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USE OF RADIOACTIVE TRACERS IN STUDIES OF THE SHOOT APEX

By Dr. A. BOOTH*, Dr. E. G. CUTTER, Dr. S. N. POSTLETHWAIT†, B. R. VOELLER‡ and Prof. P. F. WAREING§

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In studies of morphogenesis at the shoot apex, hypotheses are often advanced which involve the transport of various substances, and their accumulation at specific sites, within the meristematic regions. Such hypotheses are difficult to test by means of standard physiological techniques because of the minute volumes of tissue involved. One possible approach to these problems is the use of radioactive isotopes, which have, indeed, already been successfully employed in studies of histogenesis in root apices[1] and, more recently, in the shoot apex of *Pinus*[2]. Previous work with radioactive tracers on apical meristems has been confined to autoradiography of sectioned material, thus restricting the area of tissue which it is possible to examine at any one time. A possible technique for obtaining autoradiographs of the whole surface area of intact or surgically treated shoot apices has been devised by us. This technique renders it possible, for example, to compare in a single film autoradiographs of visible leaf primordia, prospective leaf sites and the whole surface of the shoot apex, which could never all be viewed simul-

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taneously in section. It is, however, applicable only to the investigation of phenomena occurring near the surface of the tissues.

Shoot apices of *Dryopteris aristata* (*austriaca*) were used, both because this fern has already been the subject of extensive experimental investigation and because its apical region is of suitable form for the application of the technique described, in that it comprises a central apical cone and a number of small, spirally arranged leaf primordia which are not in contact (Fig. 1). The shoot apex was exposed to view by removing the older leaves and all scales. A cylinder of rhizome tissue, bearing the apical meristem at its tip, was then removed with a cork borer (9–12 mm. diameter), and trimmed to suitable length (5–10 mm.). The number of leaf primordia present, the stage of the plastochrone, and the direction of the phyllotactic spiral were noted, and the position of the next leaf primordium to arise (I_1) was marked. After allowing a 24-hr. recovery period, the cylinders of tissue were placed in a vertical position on filter paper moistened with the isotope solution, contained in a moist glass chamber. The isotopes used in this preliminary survey were phosphorus-32 (as a solution of orthophosphate) and 8-adenine sulphate labelled with carbon-14. An activity of 3–5 μc./ml. of solution (without the addition of carrier) was found to be suitable.

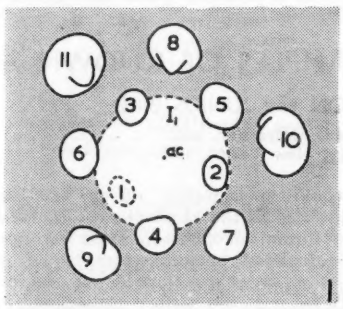

Fig. 1. Drawing of an apex of *Dryopteris aristata* similar to those from which the autoradiographs shown in Figs. 2 and 3 were obtained. Eleven young leaf primordia (P_1–P_{11}) are present; the position of I_1 (the next primordium to be formed) is also indicated. The apical cone is outlined with a broken line; the sub-apical region is stippled. *ac*, apical cell. (× 18)

The cylinders of tissue were removed from the dishes after an appropriate period of uptake, and thoroughly washed to remove any isotope solution on the surface. Thin, semi-circular slivers of tissue, about 4 mm. diameter and 1–2 mm. thick, bearing the apical meristem were excised from the cylinders and quickly affixed to small glass slides with 'Durofix'.

In a dish of water, small trapezium-shaped pieces of fast autoradiographic stripping-film (Kodak *AR* 50) were floated on to the surface of the apices and carefully orientated to allow subsequent recognition of the I_1 position. Excess water between the apex and the film was removed with filter paper; this considerably improved the subsequent fit of the film. The film was then quickly dried over the surface of the tissue with a stream of warm air from an industrial blower held at a distance of about 3 in. for 15 sec. The timing of this operation is important; with a shorter period of heating, the fit of the film was greatly impaired, whereas with more than 15 sec. heating, subsequent removal of the film from the tissue was rendered impossible. After this treatment

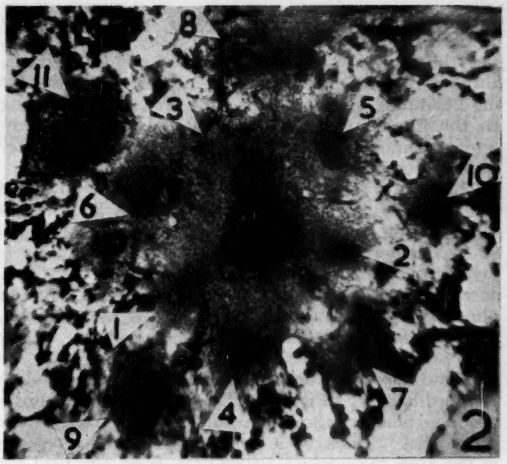

Fig. 2. Autoradiograph of an apex of *D. aristata* treated with phosphorus-32. Primordia 1–11 are present; P_8 and P_{10} were damaged. All the leaf primordia (arrowed) and the tip of the shoot apex (centre) are indicated by areas of blackening in the film. Totally dark areas, near the edge of the figure, are pieces of apical tissue adhering to the film; the film is also torn in places, leaving clear areas. Period of uptake of isotope, 6 days; film exposed for 40 hr. (× 20) (*Photo: G. Barker*)

the slide bearing the apex covered with film was placed in a light-tight container and maintained at a temperature of − 20° C. during the period of exposure. With phosphorus-32 an uptake period of 3–5 days with an exposure-time of 36–72 hr. usually gave satisfactory results, though longer periods of exposure were sometimes necessary (Fig. 3). Some differential blackening of the film was obtained after only 24-hr. uptake, with a long exposure period (11 days).

After exposure of the film, the slide was removed from its container, and the film was developed and fixed while still adhering to the apex. Since the film could not be examined satisfactorily with the opaque tissue beneath it, it was removed from the apex with fine forceps under water, and floated on to a slide. Areas of blackening on the film were then compared with the various regions of the apex, before

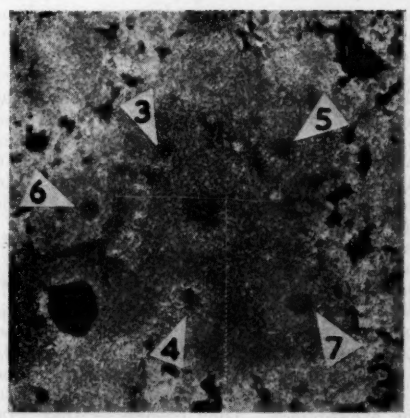

Fig. 3. Autoradiograph of an apex treated with phosphorus-32. Primordia 1–7 were present; P_1 (between 4 and 6) and P_3 (between 5 and 7) are not obvious in the film, but P_4–P_7 (arrowed) and the tip of the shoot apex (centre) are represented by blackened areas. Totally dark areas are pieces of tissue adhering to the film. Period of uptake of isotope, 3 days; film exposed for 14 days. (× 20) (*Photo: G. Barker*)

discarding the latter. Since the position of I_1 can be determined from the shape of the piece of film, and the direction of the phyllotactic spiral and the number of leaf primordia present were recorded at the beginning of the experiment, areas of blackening on the film may readily be assigned to the appropriate primordia or regions of the apex long after these tissues have been discarded.

The results thus far obtained indicate the potential usefulness of the method. Figs. 2 and 3 illustrate films obtained from apices treated with phosphorus-32. Considerable blackening due to silver grains is present over the whole area of film covering the tissue, as would be expected with an isotope of the range of phosphorus-32; but the blackening is not uniform. It is concentrated, in fact, at the positions of the leaf primordia; blacker areas can sometimes be detected down to and including the youngest leaf primordium, P_1 (Fig. 2). Damaged leaf primordia produce blackening comparable to that from intact primordia. Scales, scale primordia and those regions of the apex from which scales have been removed are recorded as paler areas in the film. The scope of the technique is not restricted to inorganic phosphorus-labelled compounds, but can be extended to organic carbon-labelled compounds, since comparable results were also obtained with adenine labelled with carbon-14. Films from control apices, placed on water containing no isotope, showed no appreciable blackening.

In conclusion, it should perhaps be emphasized that this method is still not without difficulties, and that a relatively small number of satisfactory demonstrations has been obtained from a considerable number of specimens. Moreover, these preliminary results have only demonstrated accumulations of tracer in visible primordia. The really effective contribution which we hope may be obtained from the method would be demonstrations of the accumulation of specific metabolites: (*a*) as a result of the presence of various experimental incisions, and (*b*) in the I_1, I_2 and even I_3 positions, thus providing evidence of the existence and approximate dimensions of centres of growth which are not as yet morphologically or histologically detectable. This aim has not yet been achieved, even in actively growing apices. However, in conjunction with existing experimental results and morphological techniques, it is felt that this method, when extended, may well throw light on these and other aspects of the physiology of the formative regions of plants, a difficult and little investigated field.

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RADIOCARBON MEASUREMENTS ON SAMPLES OF KNOWN AGE

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THE radiocarbon age method is at present based on the assumption that the ratio carbon-14/carbon-12 in atmospheric carbon dioxide has remained constant with time. The approximate validity of this assumption was originally demonstrated by Arnold and Libby[1], whose measurements of historically and tree-ring dated samples showed no significant deviations over the past 5,000 years (that is, none beyond 5 per cent of the age). Since then, other far more precise measurements have appeared in the literature[2–4], generally showing consistency between radiocarbon and absolute ages.

From a theoretical point of view, there are three possible reasons why the atmospheric ratio of carbon-14/carbon-12 might change with time: first, fluctuations in the rate of production of carbon-14; secondly, variations in the amount of stable carbon in the dynamic reservoir; and thirdly, variations in the pattern of inhomogeneous distribution of carbon-14 within the dynamic reservoir.

Recently the first and third possibilities have been discussed. Assuming that Thellier's[5] residual magnetism measurements of ancient French bricks typified the whole earth, Elsasser, Ney and Winckler[6] calculated that the greater magnetic field intensity in the past deflected enough cosmic radiation from the Earth to lower significantly the production-rate of carbon-14 and consequently its concentration in the atmosphere. They calculated that 2,000-yr. samples would thus give radiocarbon ages of 2,240 years. In addition, Broecker *et al.*[7], reasoning from Worthington's[8] suggestion of catastrophic overturn in the oceans, suggested that such changes in the rate of formation of deep water, if on a world-wide scale, would measurably affect the carbon-14/carbon-12 ratio in the atmosphere. If, for example, the rate of formation of bottom water were accelerated, carbon-14-depleted bottom water would reach the surface at a faster rate, reducing the carbon-14/carbon-12 ratio in the surface waters and in turn in the atmosphere. Although the results of Broecker *et al.*[7] failed to show any significant variations which might be related to non-equilibrium circulation of the oceans, DeVries[9] has recently obtained results demonstrating small oscillations ($\pm$ 1 per cent) in the ratio carbon-14/carbon-12 of the atmosphere over the past few hundred years. He feels that these variations correlate well with historical climatic records in the manner predicted if the cause were variation in the rate of formation of deep water.

By applying corrections to certain published carbon-14 measurements of samples of known age, Crowe[9] has postulated that the past few thousand years have witnessed atmospheric variations over a range of 10 per cent. Munnich, Ostlund and de Vries[10] and Barker[11] have shown, however, that Crowe's corrections are unrealistic; with more reasonable assumptions, his deviations disappear.

In order to define the atmospheric carbon-14/carbon-12 ratio over historic time, a large number of samples will have to be measured from many areas and at closely spaced times. This will necessitate the co-operation of a number of laboratories. As a contribution to the problem, a number of Lamont measurements on samples of known age are reported here (summarized in Table 1). Since the results are related to the international oxalic acid carbon-14 standard distributed by the U.S. National Bureau of

Table 1. RADIOCARBON RESULTS FOR SAMPLES OF KNOWN AGE

Absolute age (yr. before 1958)	Calendar date	Method of absolute dating	Place of growth	Type of material	$\delta^{14}C$	$\delta^{13}C$	$\Delta^{14}C$	Carbon-14 age*	Lamont No.
1879±2	A.D. 79	Historical	Pompeii, Italy	Carbonized bread	+ 8±5	−21·1	+ 1±5	1894±40	*L-371E*
1502±10	A.D. 456	Mayan calendar (Spinden correlation)	Guatemala	Wood	+ 9±7	−21·8	+ 3±7	1502±60	*L-113*
1242±10	A.D. 716	(Goodman *et al.* correlation)			−23±7		−30±7		
1384±5	A.D. 574	Ring counting	Kings Canyon National Park, Calif.	Sequoia wood	−13±7	−18·7	−26±7	1606±60	*L-108B*
886±5	A.D. 1072	Ring counting	Kings Canyon, National Park, Calif.	Sequoia wood	+12±7	−20·5	+ 3±7	886±50	*L-108A*
324±5	A.D. 1634	Ring counting	Pacific Northwest United States	Spruce wood	+19±6	−24·9	+19±6	202±50	*L-353A*
281±5	A.D. 1677	Ring counting	Pacific Northwest United States	Spruce wood	+28±6	−18·0	+15±6	166±50	*L-353C*
220±5	A.D. 1738	Ring counting	Pacific Northwest United States	Spruce wood	+12±5	−20·9	+ 4±5	204±40	*L-353E*
148±5	A.D. 1810	Ring counting	Pacific Northwest United States	Spruce wood	+16±5	−24·1	+15±5	56±40	*L-353B*
133±5	A.D. 1825	Ring counting	Pacific Northwest United States	Spruce wood	+13±5	−22·0	+ 8±5	95±40	*L-353F*
83±5	A.D. 1875	Ring counting	Pacific Northwest United States	Spruce wood	0±6	−21·4	− 7±6	160±50	*L-353D*
68±5	A.D. 1890	Ring counting	Palisades, N.Y.	Oak wood	+ 2±5	−24·0	0±5	91±40	*L-314*
68±5	A.D. 1890	Ring counting	Palisades, N.Y.	Pine wood	− 2±6	−23·0	− 6±0	0±50	*L-315*

$\Delta^{14}C$ average = +3 (excluding *L*-113). Standard deviation = 17

* Ages are computed using the average $\Delta^{14}C$ as the control value.

Standards, they can be compared directly with those obtained at other laboratories.

The results are expressed in terms of $\Delta^{14}C$, defined as follows :

$$\Delta^{14}C = \delta^{14}C - 2\delta^{13}C\left(1 + \frac{\delta^{14}C}{1{,}000}\right) - 50{\cdot}0$$

where

$$\delta^{14}C = \left\{\frac{A^*(\text{sample}) - 0{\cdot}950A^0(\text{oxalic acid})}{0{\cdot}950A^0(\text{oxalic acid})}\right\} \times 1{,}000$$

and

$$\delta^{13}C = \left\{\frac{R\,(\text{sample}) - R(\text{belemnite standard})}{R(\text{belemnite standard})}\right\} \times 1{,}000$$

Symbols used are defined as follows : $\delta^{14}C$ and $\delta^{13}C$ = per mille (not per cent) differences from arbitrary standards (consequently, $\Delta^{14}C$ is in per mille) ; A^* = carbon-14 activity of the sample corrected for radioactive decay between formation and measurement of sample ; A^0 = carbon-14 activity of the standard corrected for decay between January 1, 1958, and the time of the measurement ; R = ratio carbon-13/carbon-12 as determined on a mass spectrometer. The constants − 50·0 and 0·950 are introduced so that the values for $\Delta^{14}C$ and $\delta^{14}C$ for pre-1900 woods (the usual modern control standards of radiocarbon laboratories) fall close to zero on the scale. (A more complete discussion of the scale used in this communication will be published in the first radiocarbon supplement of the *Americal Journal of Science* (1959).) By introducing $\delta^{13}C$, a term based on the stable isotope ratio carbon-13/carbon-12 of the gas used for the radioactivity assay, the term $\delta^{14}C$ is corrected for isotope fractionation during the photosynthetic processes and/or during the laboratory preparation of the sample gas. Thus, if the ratio carbon-14/carbon-12 for the atmosphere is geographically uniform and has remained constant in the past, as at present assumed in dating, the $\Delta^{14}C$ values of all historically dated terrestrial plant materials should be the same within the experimental error.

The $\Delta^{14}C$ results of measurements on twelve samples which are dated historically or by tree-rings are listed in Table 1, as well as plotted in Fig. 1. Before examining the results for the purpose of drawing conclusions, it would be well to consider how the absolute ages of the samples were obtained.

Two samples, Pompeiian bread and Mayan lintel wood, are dated historically. The bread remains found at Pompeii were certainly charred in the great ash fall of A.D. 79, so that the age of the wheat is 1,879 years plus the period of grain storage ; the latter is probably less than two or three years and thus negligible. In the case of the lintel wood, the absolute age is obtained from the Mayan date of 9.15.0.0.0 carved on the lintel ; according to the Spinden correlation of the Mayan and Christian calendars, the date is equivalent to August 30, 481. Thus, the age of the wood is 1,477 years plus the period between growth and cutting of the tree, estimated from ring counts to be about 25 years (that is, 1,502 years). On the other hand, if the Goodman–Martinez–Thompson correlation is correct, the age is 260 years less (that is, 1,242 years).

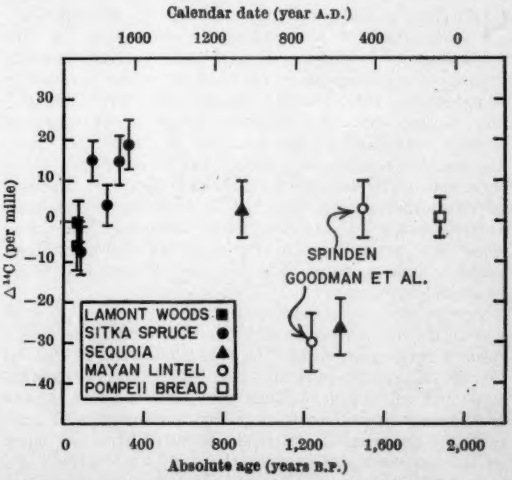

Fig. 1

The other ten samples all involve tree rings representing four individual trees, sequoia, sitka spruce, oak and pine. In all cases, the ages were obtained from the dates of cutting together with ring counts. The sequoia and spruce sections are part of the forestry collection of the American Museum of Natural History in New York City, while the oak and pine trees were obtained from the grounds of the Lamont Geological Observatory. We wish to acknowledge the aid of J. McCormack and F. Scherer, of the Museum staff, in obtaining the sitka spruce samples.

The results show a spread of ± 25 per mille about a mean of + 3 per mille. Since the standard deviation of the results is 17 per mille, in contrast to the measurement error of about 6 per mille, there is little doubt that the results include real differences. As yet it is not certain whether these results reflect world-wide or merely local variations. The three samples of highest activity (spruce woods with ages of 148, 281 and 324 years) are consistent with results obtained by both Munnich[3] and de Vries[5], pointing to a 10–20 per mille higher atmospheric carbon-14/carbon-12 ratio during the period A.D. 1630–1830. On the other hand, the 886-year-old sequoia sample and the Pompeiian bread (A.D. 79) fall close to the average and to wood grown within the last half of the nineteenth century. The results of Munnich[3] and de Vries[5] also provide support for the similarity between the atmospheric carbon-14/carbon-12 ratio of the mid- to late-nineteenth century and the late first century A.D., suggesting a difference no greater than 10 per mille. Unless further radiocarbon results fail to support this similarity, the postulated linear decrease of the Earth's magnetic field suggested by Thellier's[8] residual magnetism data is improbable. Whether the low value represented by the 1,400-year-old sequoia sample is truly representative of a world-wide condition is uncertain. If it is, then the calendar correlation of Goodman *et al.* gains support. But if the average of all samples is more typical of the Mayan atmosphere, the Spinden correlation is favoured.

From the above discussion, it should be clear that more observations on samples of known age are needed to increase the accuracy of radiocarbon dates on recent samples. The job is two-fold : (1) archæologists must be on the alert for accurately dated historical samples (± 10 years) and (2) radiocarbon laboratories must continually increase their counting precision well below the 1 per cent level, an average for the magnitude of variations sought here. With the present observations it can only be said that the radiocarbon age of an atmospherically derived sample younger than 2,000 years will almost always lie within 250 years of the true age.

We gratefully acknowledge the encouragement of Dr. J. L. Kulp in the work reported here. Thanks are also due to James Hubbard and Marylou Zickl for their aid in preparing and measuring the reported samples and to Glen Erickson and Roland Kologrivov for the mass spectrometric measurements of carbon-13/carbon-12 ratios.

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REFRACTION OF EXTRA-TERRESTRIAL RADIO WAVES IN THE IONOSPHERE

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SEVERAL authors, most recently Chvojkova[1], have derived approximate expressions for the refraction of extra-terrestrial radio waves passing through the ionosphere ; all have assumed a radially symmetrical ionospheric model. However, Smith[2] has shown that the diurnal variation of electron density, especially near sunrise, produces east–west horizontal gradients which result in appreciable changes in the apparent right ascensions of discrete sources. Also, recent work[3] at Sydney has shown that north–south gradients are just as important, and it is clear that an adequate treatment of the refraction problem must take account of departures from spherical symmetry.

For galactic observations at low frequencies, it is essential that some means of estimating the ionospheric refraction should be available, and one of us (M. M. K., in preparation) has derived new expressions for refraction, taking into account the effects of horizontal gradients in electron density and considering the magnitude of the uncertainties involved in the necessary approximations. The analysis has been restricted to the case of a transit radio telescope. Before including the effects of horizontal gradients, that is in the limiting case of a spherically symmetrical ionosphere, it is shown that a source the apparent declination of which is δ' is actually displaced from its true declination by $\Delta(\delta)_s$, where :

$$\Delta(\delta)_s = \sin^{-1}\left[\frac{r_m}{r_b}\sin I_b\right] - I_b - \sin^{-1}\left[\frac{r_m}{r_a}\sin I_a\right] + I_a - \sin^{-1}\left[\frac{r_m}{r_b}\sin(\delta' - \varphi)\right] + \sin^{-1}\left[\frac{r_m}{r_a}\sin(\delta' - \varphi)\right] \quad (1)$$

and the angles I_a, I_b are given by

$$\tan I_a = \frac{\tan(\delta' - \varphi)}{r_a - r_m}\int_{r_m}^{r_a}\frac{dr}{\mu_{f\cos(\delta' - \varphi)}}$$

$$\tan I_b = \frac{\tan(\delta' - \varphi)}{r_m - r_b}\int_{r_b}^{r_m}\frac{dr}{\mu_{f\cos(\delta' - \varphi)}}$$

Here $\mu_{f\cos(\delta' - \varphi)}$ is the refractive index, at a point on the ray with geocentric distance r, for a frequency $f\cos(\delta' - \varphi)$, f being the observing frequency and φ the observer's latitude. r_a and r_b are the radii of the upper and lower 'boundaries' of the ionosphere (that is, 95 per cent of the electrons are in the range $r_b < r < r_a$) and r_m is the radius of the layer [of

maximum electron density. Provided $(r_a - r_b) < 0{\cdot}1r_m$, the error in equation (1) does not exceed about 10 per cent.

Departures from spherical symmetry lead to extra displacements, in right ascension as well as in declination, proportional to the longitudinal and latitudinal gradients in electron density. If the shape of the layer is everywhere the same, the displacements are proportional to the gradient in f_c^2, f_c being the critical frequency of the layer. Provided the 'effective ionospheric thickness' d, defined in terms of the total electron content by $\int N\,dr = d.N_{max.}$, is constant and also that the gradients $(\partial f_c^2/\partial\varphi)$, $(\partial f_c^2/dL)$ are unidirectional throughout the ray path, then for moderate zenith angles the total change of declination, $\Delta(\delta)$, is given by :

$$\Delta(\delta)\cos^2(\delta'-\varphi) = \frac{d}{2r_b f^2}\left[f_c^2\tan(\delta'-\varphi) - \frac{\partial f_c^2}{\partial\varphi}\right] = d.\rho(\delta) \quad (2)$$

and the change of right ascension, $\Delta(\alpha)$, by :

$$\Delta(\alpha)\cos\delta'.\cos\varphi.\cos(\delta'-\varphi) = \frac{d}{2r_b f^2}\cdot\frac{\partial f_c^2}{\partial L} = d.\rho(\alpha). \quad (3)$$

The first term in $\rho(\delta)$ is an approximation from equation (1), and, in the special case defined by $\delta f_c^2/\partial\varphi = 0$, equation (2) reduces to Chvojkova's equation. It is seen that the refraction is proportional to d and hence to the total electron content, so that refraction observations give a new method of estimating this quantity.

Using the Sydney 19·7 Mc./s. Mills cross, many observations of the apparent positions of some of the stronger discrete sources have been made, and the observed refraction has been correlated with ionospheric data from the chain of ionospheric stations, along the east coast of Australia, controlled by the Australian Ionospheric Prediction Service. Values of f_c^2 and its latitudinal gradient were estimated from the simultaneous hourly values of $f0F2$ from the different stations, while the longitudinal gradient was estimated from the time variation. The results of observations of apparent declination of the sources $03S3A$, $09S1A$ and $12N1A$, made between September 1957 and May 1958, are presented graphically in Fig. 1.

There is good correlation between $\Delta(\delta).\cos^2(\delta'-\varphi)$, the refraction observed for each source reduced to a common scale, and $\rho(\delta)$ (see equation 1); we infer that for all these observations d was approximately equal to 550 km. An independent estimate obtained from the right ascension data (not shown) was 450 km., but in this case the scatter of the points was much greater. For both right ascension and declination a considerable part of the scatter is due to the uncertainties involved in interpolating from the hourly ionospheric data to the circumstances of each observation. In this connexion, the effects of large ionospheric irregularities (order of 100 km.) could be serious; short-period scintillations (order of 1 min.) have been eliminated by an averaging process in the reduction of the observations.

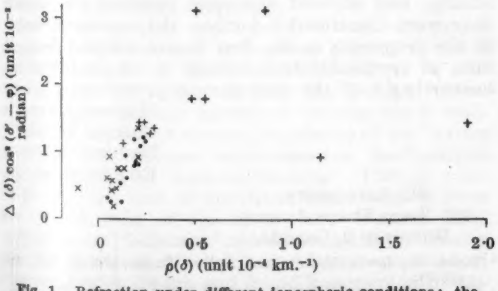

Fig. 1. Refraction under different ionospheric conditions; the quantities plotted are defined in the text. Observations of three discrete sources are indicated separately : ●, $03S3A$; +, $09S1A$; ×, $12N1A$

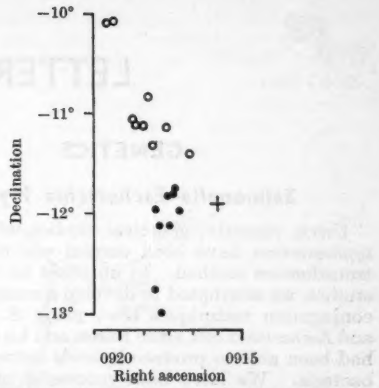

Fig. 2. 19·7 Mc./s. positions of the source $09S1A$. Observed positions are shown by circles and the positions obtained after applying corrections for ionospheric refraction are shown by dots. The cross indicates the 85·5 Mc./s. position of the source

The constancy of the value of d implies that, for these observations, the total electron content of the ionosphere was directly proportional to $(f0F2)^2$.

Evans[4] has published values of the total electron content derived from observations of moon echoes at Jodrell Bank. We have estimated the total electron content to be expected at the time of his observations, assuming the constant value of d = 500 km. deduced from our refraction measurements, and taking $f0F2$ from the Slough data. There is generally good agreement with his observational results, especially in view of the differences in place and time.

As an indication of the astronomical value of the ionospheric refraction corrections, the observed and corrected positions of $09S1A$ are shown in Fig. 2. In declination, the scatter has been much reduced and the corrected positions, with two exceptions, are within a few minutes of arc of the 85·5 Mc./s. position[5], after corrections of about 1°. The two exceptional observations are those showing very large refraction and they have obviously been over-corrected; this is probably due to the effects of ionospheric irregularities. In right ascension the scatter is reduced, but there is a systematic shift from the 85·5 Mc./s. position; similar shifts have also been found in the observations of $03S3A$ and $12N1A$. Since we believe that any aerial collimation error is much smaller than this, the results suggest that there were large density gradients (density increasing to the east) in the F-region which were not reflected in $f0F2$. These gradients must have occurred above the level of maximum ionization density, and were presumably associated with the early morning conditions under which most of the observations were taken.

A more detailed account of these and other experimental results is being prepared for publication.

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LETTERS TO THE EDITORS

GENETICS

Salmonella–Escherichia Hybrids

Until recently, genetical studies with *Salmonella typhimurium* have been carried out mainly by the transduction method. In an effort to facilitate such studies, we attempted to develop a means of applying conjugation techniques also, using *S. typhimurium* and *Escherichia coli*, since Baron and his collaborators[1] had been able to produce hybrids between these two bacteria. We have been successful in experiments with a *Salmonella* culture carrying a mutator gene (*mut*) and a culture of *E. coli* strain *K*-12 carrying the factor for high frequency of recombination (*Hfr*). The mutator strain was isolated by Miyake[2] from strain *LT*-7. Its main characteristic is a 10- to 100-fold increase in spontaneous mutability.

Our procedure for the detection of recombinants is as follows. Equal volumes of over-night broth cultures of the *S. typhimurium mut* strain and *E. coli Hfr* are mixed; 0·1-ml. samples of the mixture are plated immediately on appropriate medium; and the plates are incubated for 24–36 hr. at 37° C. Under these conditions the frequency of recombinants is about 1 per 10^6 plated bacteria. Thus it is considerably lower than the frequency observed in recombination between two strains of *E. coli*.

Two *E. coli* strains have been used so far: *HfrCS*101 and *HfrC*. With the first we obtained hybrids in which the following *S. typhimurium* mutant genes were replaced by their wild-type alleles from the *E. coli* genome: ability to ferment lactose (*lac*); requirements for leucine (*leu*), arginine (*arg*), threonine (*thr*), aspartic acid (*asa*), thiamine (*thi*), proline (*pro*), glutamic acid (*glt*) and pantothenate (*pan*). With *HfrC* we have obtained hybrids incorporating the *lac*, *pro*, *leu* and *thr* wild-type alleles.

Thus it appears likely that the hybrids may carry any region of chromosome of the donor bacterium.

The results so far can be summarized as follows:

(1) Hybrids have been obtained which combine certain genetic markers carried separately by the two parent bacterial strains.

(2) Among these hybrids three types have been recognized: (*a*) sensitive to virulent *Salmonella* phage *H*5, but resistant to *E. coli* phage *T*6; agglutinated by *Salmonella* serum; (*b*) resistant to phages *H*5 and *T*6; very slight or no agglutination by *Salmonella* serum; (*c*) resistant to phage *H*5, but sensitive to *T*6; not agglutinated by *Salmonella* serum.

(3) Temperate *Salmonella* phage (*PLT*-22 *H*1) grown on a type-(*a*) hybrid will transduce markers carried in the *Salmonella* part of the chromosomal complex, provided the recipient *Salmonella* bacteria have the *mut* (mutator) gene.

(4) This same phage forms about 10^1–10^2 times more plaques on hybrid-(*a*) bacteria than on *LT*-7 bacteria carrying the *mut* gene, and 10^3–10^4 times more plaques than on *LT*-7 bacteria without *mut*. Adsorption tests indicate no difference between hybrid *LT*-7 *mut* and *LT*-7 *mut*$^+$ bacteria with regard to phage adsorption.

(5) The approximate order of certain loci in the *Salmonella* genome as determined by these recombination tests is: *mut—thr—leu—pan—pro—lac*. There is evidence that *pro* and *lac* are close together and close also to *asa*, *glt* and *arg*.

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A Further Example of the Kell Blood Group Phenotype K−,k−,Kp(a−b−)

In an earlier communication[1], we reported two sisters having the Kell phenotype K−,k−,Kp(a−b−). The parents were second cousins, and it was assumed that the sisters were homozygous for a Kell gene the product of which does not react with any of the known Kell antisera. Allen *et al.*[2] later gave this gene the abbreviation K°. Alternatively, there may be a deletion or suppression. We have sought for other examples of this phenotype by using the serum of the propositus of the above family by the capillary-papain method[3]; by this method the serum reacts with all K+ or k+ bloods. The 3,122nd blood so tested did not react, indicating that it was of the phenotype we sought. This was confirmed by testing with anti-K, anti-k, anti-Kp^a and anti-kp^b; it reacted with none of these.

The parents of the propositus, Mrs. Kan, are first cousins. Her husband, two children, daughter-in-law and four grandchildren are all K−,k+,Kp(a−b+). While the two children are presumably of genotype kKp^b.K°, titration with anti-k and with anti-Kp^b failed to differentiate between assumed genotypes kKp^b.kKp^b and kKp^b.K°. The family is of Finnish descent. The mother and six brothers and sisters of the propositus live in Finland.

It may or may not be significant that two members of the original family in which K° occurred, and two of the nine members examined in the present sibship, had suffered abnormal bleeding for which they were transfused; further, the new-born baby of the propositus in the first family suffered from a form of erythroblastosis fœtalis in which petechial hæmorrhages of the skin were a prominent sign.

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BIOLOGY

The River Niger as a Barrier in the Spread Eastwards of Hæmoglobin C: a Survey of Hæmoglobins in the Ibo

HÆMOGLOBIN C is associated with West Africa rather than with Africa as a whole. It differs in that respect from hæmoglobin S, which is distributed throughout that continent south of the Sahara and north of the River Zambezi. Within West Africa the highest incidences are found in northern Ghana, where Dagomba, Moshie and Dagarti were seen to include 28, 22, and 16·5 per cent, respectively, of people with hæmoglobin C (ref. 1). Similar high incidences were found in the French territories bordering northern Ghana[2]. East of Ghana hæmoglobin C is still found at an appreciable incidence as far as Western Nigeria in the Yoruba. Thus Allison[3] saw hæmoglobin C in 6 per cent of 104 Yoruba resident in Ghana, and Walters and Lehmann[4] in 7 per cent of 940 inhabitants of a Yoruba village 40 miles north-east of Lagos. Garlick and Barnicot[5] examined 305 Yoruba school-children in Ibadan and found hæmoglobin C in 6·5 per cent.

Though isolated examples of hæmoglobin C have been reported from areas farther east than western Nigeria, surveys have generally failed to show it at an appreciable incidence anywhere east of the River Niger. Walters and Lehmann[4] found no hæmoglobin C in 155 Igalla, a tribe closely related to the Yoruba but differing from them by having remained east of the River Niger in the course of the migration which carried Yoruba and Igalla first from the Sudan to the Bornu Province and later to their present homes. The difference in the genetic make-up of Yoruba and Igalla was attributed to the fact that by crossing the River Niger (Fig. 1) and by invading the coastal forest belt the Yoruba had become involved in warfare with tribes from Dahomy and Ghana to the west, and that raids and counter-raids must have resulted in interchange of captives which would have introduced hæmoglobin C into the Yoruba. The Igalla live in an area lying in the angle formed by the Niger in the west and its main tributary, the Benue, to the north. Hæmoglobin C has also been sought for in the Lake Chad area in the extreme north-east of Nigeria, when Roberts and Lehmann[6] found no hæmoglobin C in 105 Shuva, 116 Kanouri and 92 Bedduwa, but 6 carriers of hæmoglobin C trait among 104 Wakura. South of this region, Langouillon and Delas[7] failed to find hæmoglobin C in an extended survey, with one exception, where 224 Southern Cameroon Bantu included 1 carrier of the hæmoglobin C trait. In all these surveys hæmoglobin S was found at high frequency.

As it seems that hæmoglobin C falls sharply in frequency from west to east within Nigeria, it was of special interest to determine the incidence of this hæmoglobin in people east of the Yoruba, where about 7 per cent are carriers of hæmoglobin C trait. The most important eastern neighbours of the Yoruba are the Ibo, whose administrative headquarters are in Enugu in Eastern Nigeria. Though most of the Ibo live east of the River Niger, some of them are found west of the river—'the Western Ibo'. Edington and Lehmann[1] noted hæmoglobin C among the Ibo resident in Accra, and Allison[3] examined 51 Ibo resident in Ghana and found 3 carriers of hæmoglobin C trait among them. This sample, however, is small, and as the Ibo lived in Ghana it was possible that there had been some local admixture. An undoubted case of hæmoglobin C disease in an Ibo has been seen in Enugu by Nwokolo[8].

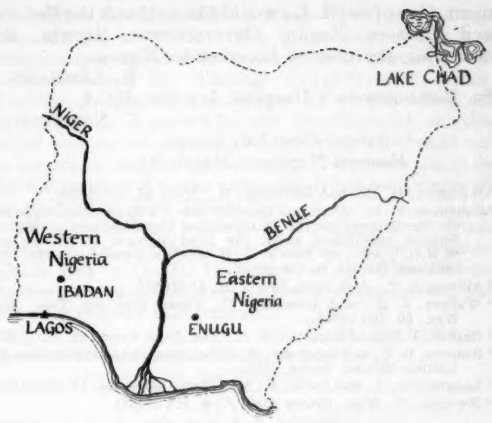

Fig. 1

We examined 257 non-related Ibo, of whom 4 came from west of the River Niger (Western Ibo) and 253 from areas in Eastern Nigeria. 36 were women-teachers attending a training college in Enugu, 17 were nurses at the Enugu General Hospital, 70 were out-patients at a leper hospital in Uzuakoli, and 134 were school-children. Of the school-children, 18 were seen in Lagos and are included in this survey by the kind permission of Dr. W. dos Santos, senior pathologist, Federal Government Medical Services, Nigeria, and the remainder at three different schools in Enugu.

The total number of school-children examined in this survey was 260, but these included non-Ibo: 108 Yoruba and the rest Ibibio, Effik and others. An interesting chance finding was the sickle-cell thalassæmia pattern (S + A + F) in one of the non-Ibo school-children examined. The child came from Benin and the family was resident in Ishan. It is of interest that Benin was exposed to a sustained Portuguese influence in the past, and the finding of thalassæmia in a child coming from Benin might indicate how the classical thalassæmia gene—which is only occasionally discovered in Africa—might have entered that continent.

Table 1. HÆMOGLOBINS IN 257 NON-RELATED IBO

Phenotype	AA	AS	AC	AG
Number	190	64	2	1

Except for the Yoruba, hæmoglobin C was only seen among the Ibo and, as Table 1 shows, there were 2 carriers of the hæmoglobin C trait among the 257 examined. The incidence of 24·9 per cent sickle-cell trait carriers among the Ibo is similar to that in the neighbouring communities of West Africa, and the finding of hæmoglobin G in one Ibo is the first example of this hæmoglobin in Eastern Nigeria. The sharp fall in the incidence of hæmoglobin C from 7 per cent in the Yoruba to less than 1 per cent farther east in the Ibo suggests that the River Niger has acted as a barrier to the spread of hæmoglobin C towards the east. The influence of that river on the distribution of hæmoglobin C is not unlike that of the river Zambezi on the distribution of hæmoglobin S.

We thank Dr. J. U. Ekpo, Enugu, and Dr. C. K. Manuel for their help with the examination of the school-children in Enugu, and Mr. E. S. Drewett for arranging the survey at the Uzuakoli Leper Settle-

ment. One of us (H. L.) would like to thank the Federal and Eastern Region Governments, Nigeria, for defraying the cost of his visit to Nigeria.

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Interaction between Ants on a Scent Trail

It is well known that many ants lay scent trails on the ground which can be followed by other ants[1–3]. When an ant is following such a trail it is guided primarily by the scent 'marks', although other orientating factors, including visual stimuli, are sometimes also involved[3,4]. Carthy[3] has suggested that another factor contributing to the dense trails formed by *Acanthomyops fuliginosus* workers might be a tendency for workers to seek maximal contact with their companions. During a study of the trail systems of the ant *Monomorium pharaonis*[4] it was possible to record the behaviour of successive workers arriving at a branch in the trail system, and to relate this to the behaviour of the preceding ant. At such a branch each ant took either branch A or branch B, and if the proportion of all ants which took branch A was p, the proportion which took B would be $(1-p)$. If there were no relation between the 'choice' of one ant and that of the following ant the expected proportions of pairs of successive ants taking respectively A and A, A and B, B and A and B and B would be p^2, $p(1-p)$, $p(1-p)$ and $(1-p)^2$. Table 1 shows that the observed proportions conform very closely with these figures and do not differ from them significantly in a χ^2 test ($\chi^2 = 2{\cdot}02$ with 3 degrees of freedom, $P >$ 50 per cent).

Table 1. Relation between the 'Choice' made by One Ant between Two Trails A and B and the 'Choice' made by the Following Ant. Figures for All Ants

Choice of first ant / Choice of second ant	A	B	A	B	Totals A	B	All
Observed numbers	48	63	64	58	112	121	233
Expected numbers	52·9	58·1	58·1	63·9			(233)
Contribution to χ^2	0·45	0·43	0·60	0·54			2·02

As the trails of *Monomorium pharaonis* are not very dense this result is not surprising. *M. pharaonis* were not, however, evenly distributed along the trails, but often ran close behind one another, perhaps simply because quicker ants caught up slower ones. When only such pairs of ants running almost if not quite in contact are considered, both ants of the pair took the same branch of the trail significantly more often than would have been expected if no interaction took place (Table 2, $\chi^2 = 6{\cdot}16$ with 1 degree of freedom, P lies between 1 and 2 per cent). In Table 2 different grouping of the results was necessary because of the smaller numbers involved, but the method by which the expected distribution was calculated was the same as in Table 1. As well as the sixteen pairs on which Table 2 was based there were four groups of three ants and one of seven ants, but such small numbers do not allow any conclusions to be drawn.

Table 2. Relation between the 'Choice' made by One Ant and that of the Following Ant. Figures only for those Ants running in Pairs

	Chose the same branch	Chose different branches	Total
Observed number	13	3	16
Expected number	8·03	7·97	16
Contribution to χ^2	3·07	3·09	6·16

Apparently in *Monomorium pharaonis* one ant does tend to follow the course taken by another provided that the two are running so close together as to be almost in contact. According to Hingston[5] *Camponotus sericeus* and *C. paria* behave in a similar way. These ants, however, do not lay scent trails and the recruits reach newly discovered food by following its discoverer on the latter's return to the food from the nest. It seems possible that the trail-laying behaviour of Myrmicine ants has evolved through such a stage where one ant led another directly, and it is therefore interesting to find traces of such behaviour in *Monomorium pharaonis*.

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Mechanical Transmission of Cassava Brown Streak Virus

Brown streak virus disease of cassava (*Manihot utilissima* Pohl.) is important in all the cassava-growing areas on the coasts of Kenya and Tanganyika, because necrosis of the starch storage tissues of the roots and stems of infected plants results in serious losses in yield[1,2]. Transmission of the virus by a white fly (*Bemisia* sp.) is suspected but has not been confirmed[2] and the only reliable means of transmitting it experimentally has been by grafting. The symptoms of the disease vary greatly with variety and environmental conditions, making diagnosis difficult, particularly when plants are infected both with brown streak and cassava mosaic, another virus disease. Thus a major difficulty in studying brown streak has so far been the lack of a means of transmitting the causal virus readily and also uncontaminated with cassava mosaic virus.

A virus causing typical brown streak symptoms in cassava seedlings has now been transmitted mechanically from cassava to several solanaceous plants. Mature leaves from infected cassava plants were macerated in water with alumina powder and 'Celite' and the extract inoculated by rubbing on the leaves of various test plants. Using this method, virus was readily transmitted to susceptible test plants, but similar extracts from young leaves gave no infections.

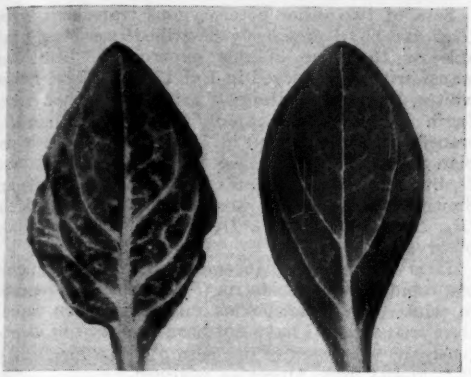

Fig. 1. Leaf of infected *Petunia* (left) with healthy leaf for comparison

Infected *Petunia hybrida* Vilm. plants were stunted and their leaves showed vein chlorosis and necrosis and were crinkled (Fig. 1). In *Datura stramonium* L. a systemic chlorosis of the fine veins developed in summer but only necrotic local lesions in inoculated leaves in winter. Inoculated tobacco (*Nicotiana tabacum* L.) leaves developed only local necrotic lesions but leaves of infected *N. rustica* L. and *N. glutinosa* L. plants showed a mild systemic vein-chlorosis. Cassava seedlings were infected by rubbing both with extracts from infected cassava and *Petunia* plants and showed symptoms consisting of a range of chlorotic patterns on the leaves similar to those described by Storey[1] and Nichols[2]. The characteristic sepia-coloured necrosis developed in the roots of some plants (Fig. 2). Though some of the cassava source-plants were infected with cassava mosaic virus, there was no indication that this was transmitted to any host by the method used.

Petunia was the most susceptible host plant found and it was used in studies on the properties of the virus. In infective *Petunia* sap cassava brown streak was rather unstable with a longevity *in vitro* of less than 24 hr. at 20° C. The infectivity of sap was drastically reduced after heating for 10 min. at 50° C. and abolished by diluting 1 : 1,000 with water. Further studies on the properties of the virus are in progress; meanwhile the development of this rapid and certain method of transmission should aid in diagnosis and in the indexing of cassava varieties for the resistance to the virus which has been reported by workers in East Africa[3,4].

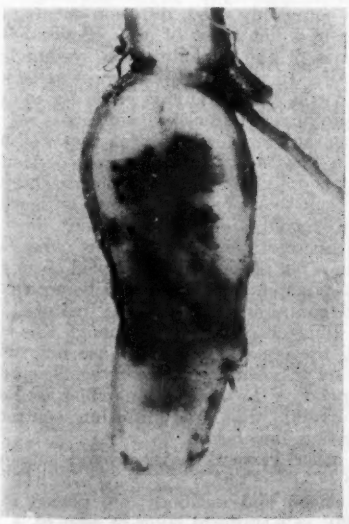

Fig. 2. Section of root of cassava seedling infected with virus from *Petunia*

Thanks are due to Mr. D. L. Jennings, now of this Institute, for obtaining the infected cassava source-plants and to Dr. H. H. Storey, of the East African Agriculture and Forestry Research Organization, for his co-operation and interest.

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Serum Transferrins

Genetically controlled variations in the β-globulins of normal human and cattle sera have recently been demonstrated by starch-gel electrophoresis[1–6]. Evidence has been presented[7] suggesting that the variable β-globulins in man are iron-binding serum proteins (transferrins). We have confirmed this directly by demonstrating with autoradiographs that iron-59 is bound specifically to the variable β-globulins in human sera, and also in cattle sera. The variable serum β-globulins in man and cattle are thus transferrins.

The results of an experiment to demonstrate the iron-binding properties of the variable serum β-globulins in humans are presented in Fig. 1. Approximately 2 μgm. of iron (containing 5 μc. iron-59) were added, as ferrous sulphate, to each ml. of serum; 0·05 ml. samples of the sera containing iron-59 (from 5 individuals) were subjected to vertical starch-gel electrophoresis[8]. The gel was cut into two slices. One slice was stained for protein (left-hand photograph in the figure); the other was used to make an autoradiograph (right-hand photograph in the figure) by placing the gel slice, wrapped in non-porous transparent film ('Saran Wrap', Dow Chemical Corporation), in contact with Kodak 'No-screen' X-ray film for 12 hr. The film was developed for 3 min. at 20° C. in Kodak formula *D*8 developer. The iron-59 is clearly bound to the variable β-globulins (indicated in the figure by white dots), which demonstrates that these proteins are transferrins. The faster migrating transferrin in each serum appears to bind relatively more iron-59 than the slower transferrin. The diffuse area of radioactivity near the sample insertion positions of some of the sera was due to the addition of more iron than could be bound by the transferrins, leading to the precipitation of inorganic iron in the gel. Addition of more serum (not containing added iron) to these samples caused the radioactivity to be confined entirely to the transferrins.

Only one transferrin (*C*) is present in the serum of the majority of individuals in all racial groups yet studied; such persons are thought to be homozygous for the genes corresponding to transferrin *C*. Two transferrins can be detected in the serum of individuals

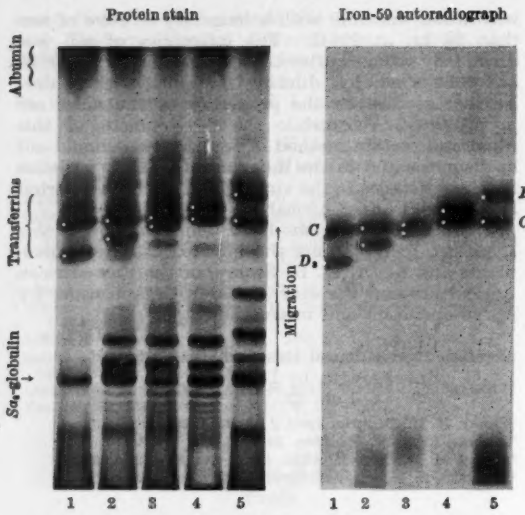

Fig. 1. The results of a vertical starch-gel electrophoresis (ref. 8) experiment with five sera containing iron-59 (plus hæmoglobin) from human individuals presumed to be heterozygous for transferrin genes. The left-hand photograph shows the protein-stained gel slice (from the sample slots to the albumin). The right-hand photograph shows the autoradiograph obtained with a second slice from the same gel. The diffuse patches of iron-59 near the sample slots are due to precipitated inorganic iron. The sera from left to right were of transferrin types (see text): 1, CD_2; 2, CD_1; 3, CD_0; 4, B_2C; 5, B_0C. The transferrin zones are indicated in the figure by white dots

who are heterozygous for transferrin genes[2–4,7]. The five sera used for the experiment illustrated were all from individuals presumed to be heterozygous for genes corresponding to transferrin *C* and to an additional transferrin (different in each of these five persons); three of the transferrin types illustrated (1, 3 and 5) have not been previously described:

Serum 1; *transferrin type* CD_2. Serum of this 'new' transferrin type, provisionally designated CD_2, was observed in 1 of 493 American negroes from Seattle (H. Harris, personal communication, has recently encountered a serum of the same type). Transferrin D_2 migrates in starch gels more slowly than any transferrin previously reported.

Serum 2; *transferrin type* CD_1. This serum was from an Australian aborigine. Sera of the same transferrin type, originally referred to as β-globulin type *CD* by Horsfall and Smithies[2], have been observed in approximately 10 per cent of Australian aborigines[3,7] and American negroes (E. R. Giblett and J. Chase, unpublished data). Comparison of a serum of transferrin type CD_1 with serum of the β-globulin type CD_1 of Harris, Robson and Siniscalco[4] indicates their equivalence. Harris *et al.* observed 3 sera of this type in 153 from Gambian negroes.

Serum 3; *transferrin type* CD_0. This 'new' type, provisionally designated CD_0, was observed in 1 of 493 sera from American negroes.

Serum 4; *transferrin type* B_2C. Serum of this transferrin type, originally referred to as β-globulin type *BC* by Smithies[2], has been identified with the type B_2C since reported by Harris *et al.*[4]. Sera of transferrin type B_2C were observed in 5 of 425 Canadian whites[3], and in 1 of 139 British whites[4].

Serum 5; *transferrin type* B_0C. This 'new' transferrin type was observed in 1 of 100 sera from American whites. Transferrin B_0 migrates in starch gels more rapidly than any transferrin previously observed.

Sera of two other heterozygous transferrin types (B_1C and CD_2) previously described[4] were not available at the time of this experiment. However, transferrin B_1, observed in 1 of 139 sera from British whites, migrates in the gels less rapidly than transferrin B_0 but more rapidly than transferrin B_2; transferrin D_2, observed in 1 of 153 sera from Gambian negroes, migrates less rapidly than transferrin D_1 but more rapidly than transferrin D_3 (Harris and Smithies, unpublished work). Thus 8 transferrins (B_0, B_1, B_2, *C*, D_0, D_1, D_2 and D_3) have now been observed in man.

It is interesting that transferrins which migrate less rapidly than transferrin *C* have not been reported in whites, and transferrins migrating more rapidly than transferrin *C* have not been observed in negroes (with the exception of one serum of transferrin type B_2C in 493 from American negroes).

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Estimation of the Size of Antigens by Gel Diffusion Methods

Analysis of the pattern of precipitation lines formed when antigens and antibodies diffuse towards one another in an agar gel is established as a valuable qualitative technique in immunology. In the systems commonly used, diffusion occurs either in a tube[1] or in a flat sheet of gel[2]. Several theoretical treatments of the tube-diffusion system have been presented[3]. In the latest, and most satisfactory, by Augustin *et al.*[4], a formula is given for calculation of the approximate diffusion coefficients of antigens from accurate measurements of the position of the precipitin lines at various intervals of time. Great accuracy is not claimed for the method, however, and it is difficult to apply when several antigens are present. Korngold and van Leeuwen[5] have given a theoretical treatment for systems where diffusion occurs in a flat sheet, which enabled them to deduce that the precipitation line would be convex towards the well containing the reacting material with the greater diffusion constant. Although this conclusion is valid, the equations derived are not suitable for calculation of accurate diffusion coefficients because they depend on the assumption, which we have found to be invalid, that free diffusion continues after precipitation has begun.

Two other systems have proved satisfactory in practice.

(1) Antigen and antibody are placed in troughs cut at 90° in a uniform layer of agar on a flat glass plate. This arrangement resembles that suggested by Elek[2], who showed that in such a system precipita-

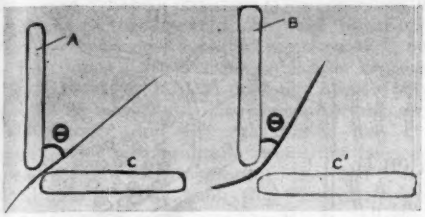

Fig. 1. Photographs of stained precipitation lines obtained by diffusion of antigen and antibody in agar gel from wells at right-angles to one another. *A*, Human serum transferrin, $\theta = 51°$; *B*, human serum β-lipoprotein, $\theta = 28°$; *C*, *C'* corresponding antisera

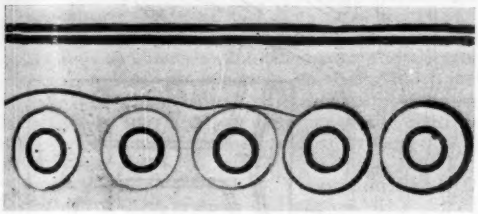

Fig. 2. Limitation of passage of human serum albumin through gelatin gels of increasing concentration

tion occurs at optimal proportions along a plane which, viewed from above, appears as a line. It can be shown that, when the amounts of antigen and antibody in the troughs are such as to give optimum proportions, precipitation will occur along a straight line inclined at an angle θ° to the antigen trough, such that $\tan\theta = (D_g/D_b)^{1/2}$, where D_g and D_b are diffusion coefficients of antigen and antibody respectively. This relationship holds true even though free diffusion is disturbed by precipitation of the reagents, but a truly straight line is formed only when the proportions of antigen and antibody in the troughs are correct. In practice, narrow straight precipitation lines are obtained within quite a wide range of relative concentrations; but when the proportions are grossly incorrect, a diffuse curved precipitate band is formed which spreads towards the trough containing the weaker reagent. Different antigen–antibody systems are precipitated independently of one another or of inert proteins present, and the diffusion coefficient of each component in a mixture can be measured, provided that the relative proportions of antigen and antibody are adjusted to be about optimal for each antigen–antibody system. Photographs of precipitate lines obtained with two representative antigens differing widely in molecular weight are shown in Fig 1. The angles of the lines are measured to within ½° on a 10 × magnified image projected on to a ground-glass screen. In Table 1 are summarized the diffusion coefficients calculated for a range of test antigens by this method, with reference to rabbit antibody, the diffusion coefficient of which was taken[5] as $3{\cdot}8 \times 10^{-7}$ cm.^{2} sec.$^{-1}$. The agreement with the values obtained by conventional techniques is good. These values are taken from the following sources: hen's ovalbumin, human serum albumin, human γ-globulin (Kabat, E. A., and Mayer, M. M. "Experimental Immunochemistry", C. C. Thomas, Springfield, Ill., 1948); human serum transferrin (Schultze, H. E., Heide, K., and Müller, H., *Behringwerk-Mitt.*, No. 31, 24; 1957); rat liver catalase (Price, V. E., and Greenfield, R. E., *J. Biol. Chem.*, **209**, 363; 1954); sheep thyroglobulin (O'Donnell, I. J., Baldwin, R. L., and Williams, J. W., *Biochim. Biophys. Acta*, **28**, 294; 1957); human serum β-lipoprotein (Levine, L., Kauffman, D. L., and Brown, R. K., *J. Exp. Med.*, **102**, 105; 1955); mouse γ-globulin (Nathans, D., Fahey, J. L., and Potter, M., *J. Exp. Med.*, **108**, 121; 1958, and unpublished observations); mouse urinary protein (unpublished measurements by Dr. P. C. Charlwood).

(2) An alternative technique depends upon the 'molecular sieve' properties of agar and gelatin gels, in which the size of the 'pores' or spaces within the solid phase becomes smaller as the concentration of solid increases. Polson[6] has presented evidence that penetration of proteins into agar gels is limited by their size (Table 2). We have studied agar, which forms suitable gels at concentrations of 1–7 per cent (w/v), and gelatin, which can be used at concentrations of 4–40 per cent (w/v). A convenient technique is shown in Fig. 2. A layer of 1·5 per cent agar (depth 2 mm.) is poured on a flat glass plate 10 cm. × 10 cm., and, after setting, holes are cut out with a cork borer. The holes are filled with molten gelatin or agar solutions of varying concentration (gelatin dissolved by heating in *M*/15 phosphate buffer *p*H 7·0 at 60°, and agar at 100°). When these plugs have set, holes with 3–4 mm. smaller diameter are cut out from the centres and sealed, leaving hollow cylinders of concentrated gelatin or agar. A narrow trough for antiserum is cut 7–8 mm. from the cylinders, and the plate is set aside for 24 hr. at room temperature for the gelatin to 'mature'. Antigen is then placed inside the cylinders and antiserum in the trough. After 1–2 days, lines of precipitate appear in the agar near those cylinders through which sufficient antigen has diffused, and lines due to common antigens fuse together. When the concentration of gel in the cylinder is high enough to prevent significant passage of antigen, no line is formed in the agar, and the line from the neighbouring cylinder appears to pass into the cylinder in question (Fig. 2). This is taken as the end-point, and is readily reproducible over a wide range of concentration of antigen and antibody. In mixtures of antigens, each reaches its end-point independently. Some results with reference antigens are given in Table 3. The technique permits estimation of the order of the effective size of antigens to within ± 30 per cent. Thus ovalbumin (mol. wt.

Table 1. Diffusion Coefficients ($\times 10^{-7}$ cm.^{2} sec.$^{-1}$) of Antigens calculated from Agar Precipitation Lines and as measured by Other Techniques

Protein	θ	Calculated D_{20}	Reported D_{20}	Molecular weight
Mouse urinary protein	58°	9·6	9·7	17,000
Hen's ovalbumin	54°	7·1	7·7	43,800
Human serum albumin	52°	6·1	6·1	70,000
Human serum transferrin	51°	5·7	5·8	88,000
Human γ-globulin	45°	3·8	3·6	177,000
Mouse γ-globulin	45°	3·8	3·9	160,000
Rat liver catalase	45°	3·8	4·1	249,000
Sheep thyroglobulin	38°	2·3	2·6	660,000
Human serum β-lipoprotein	28°	1·1	0·98	2,770,000

Table 2. Percentages (w/v) of Agar-limiting Penetration of Antigens

Protein	Estimated molecular weight	Concentration of agar
Caminella hæmocyanin	6,600,000	3 (ref. 6)
Human serum β-lipoprotein	2,770,000	5
Sheep thyroglobulin	660,000	7
Jasus hæmocyanin	450,000	7 (ref. 6)

Table 3. Percentages (w/v) of Gelatin-limiting Penetration of Antigens

Protein	Estimated molecular weight	Concentration of gelatin
Human serum β-lipoprotein	2,770,000	5
Sheep thyroglobulin	660,000	7
Human and rat serum γ-globulin	177,000	18
Human serum transferrin	88,000	26
Human serum albumin	70,000	28
Hen's ovalbumin	44,000	32
Mouse urinary protein	17,000	>40

44,000) is consistently distinguished from human serum albumin (mol. wt. 70,000).

These two methods have already proved useful in estimating the size of virus antigens. Their advantage lies in the fact that values for diffusion coefficients or size of components of a mixture of antigens can be obtained at an early stage of purification. Further details and a theoretical analysis of the diffusion systems used will be submitted for publication in *Immunology*.

We are indebted to Mr. A. G. Ward, of the British Gelatin and Glue Research Association, for supplies of high-grade gelatin, and to Drs. P. G. H. Gell, T. S. Work and B. A. Askonas for gifts of β-lipoprotein, catalase and thyroglobulin, and antisera against them.

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Electron Microscopy of Synaptic Contacts on Dendrite Spines of the Cerebral Cortex

When stained by the Golgi or methylene-blue method for light microscopy, certain dendrites of the cerebral cortex and elsewhere appear to have numerous spinous projections[1]. The nature of these spines has long been disputed. For example, it has been suggested that they are simply 'nutritive' expansions, or pre-synaptic end-feet, or post-synaptic processes of the dendrite—the pre-synaptic component remaining unstained[1-3]. Electron microscopy shows that the spines are in fact sites of synaptic contact.

The rat visual cortex was fixed with buffered osmium tetroxide, 'stained' with alcoholic phosphotungstic acid and embedded in araldite for sectioning[4].

Dendrites, which can be identified by their tubules[4,5], are often seen to have spinous projections. A spine (Fig. 1) is 2μ or less long and its stalk (*b*) may be as narrow as 0·1μ. The dendrite tubules (*den. t.*) are absent from the spine, which, however, frequently contains granular material. A structure, here termed the spine apparatus (*a*), often appears in the spine cytoplasm. It consists of two, three or more clear spaces (profiles of sacs, vesicles or continuous channels ?) and between each pair of opposed membranes of these 'sacs' a dense line occurs. No function can be ascribed to the spine apparatus at present. So far it has not been observed in the cytoplasm of the dendrite trunk or perikaryon.

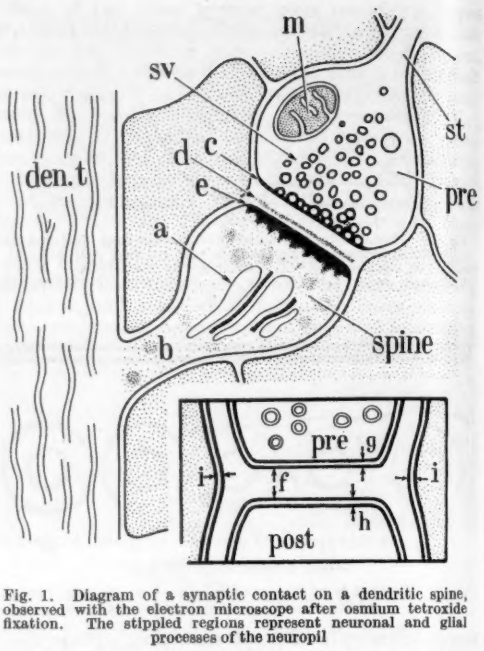

Fig. 1. Diagram of a synaptic contact on a dendritic spine, observed with the electron microscope after osmium tetroxide fixation. The stippled regions represent neuronal and glial processes of the neuropil

Inset. The opposed regions of the pre- and post-synaptic membranes seen after potassium permanganate fixation. The membranes (*i*) are of neighbouring processes of the neuropil

A pre-synaptic process (Fig. 1, *pre*) contacts the tip of the spine. The end-foot is commonly about 1μ in diameter and its stalk (*st*) (pre-terminal axon) is commonly 0·2–0·3μ in diameter. The synaptic relationship is similar to that described previously[4] for synapses formed directly with dendrite trunks. These have been termed type 1. Type 2 synapses (similar to those found elsewhere in the central nervous system) occur only on dendrite trunks and perikarya[4].

Briefly, a section of the pre-synaptic process contains usually one mitochondrion (*m*) and numerous synaptic vesicles (*sv*). Some lie in contact with the pre-synaptic membrane (*c*). Those nearest the membrane often appear denser. The pre-synaptic and post-synaptic membranes (*c* and *e*) lie 250–300 A. apart and in the extra-cellular region between them a band of electron-scattering material (*d*) occurs, sometimes slightly nearer the post- than the pre-synaptic membrane. Dense material appears associated with the cytoplasmic surface of the post-synaptic (spine) membrane (*e*). The pre-synaptic membrane (*c*), where it is opposed to the post-synaptic membrane, usually appears denser and sometimes thicker than elsewhere.

For comparison with this picture after osmium fixation the synaptic membranes have also been observed after fixation with potassium permanganate (Fig. 1, inset). Robertson[6] has described the unit membrane configuration present at cell surfaces and interpreted it in terms of organized lipid molecules. I confirm that the unit membrane structure is characteristic of cell processes of the cerebral cortex. The pre- and post-synaptic membranes (between arrows *g* and *h*) show the unit membrane consisting of two parallel dense lines, each ~ 20 A. thick, and a clear intervening layer ~ 30 A. thick. The measurement of the gap between

pre- and post-synaptic processes (*f*) is consistent with the osmium picture in that the zone between the opposed pre- and post-synaptic membranes is wider than the zones between non-synaptic processes[4]. The dense band (*d*, Fig. 1) does not appear in permanganate preparations. It appears to be extracellular material and not the middle line of an external compound membrane[6], since the line occurs when the gap between membranes is closed; in this case the gap is wider than that between opposed non-synaptic processes.

In permanganate preparations (Fig. 1, inset) the dense material associated particularly with the post-synaptic membrane does not appear: nor do the synaptic vesicles nearest the pre-synaptic membrane appear denser.

The spine seen with the light microscope in suitable preparations can thus be identified with the electron microscope. The pre-synaptic end-feet, only just visible by light microscopy[7], can also readily be seen. Similar end-feet (type 1) are common on the dendrite trunks but not neuron perikarya. A full report will be published elsewhere.

I am indebted to Prof. J. Z. Young and Dr. J. D. Robertson for their interest and advice.

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Identity of the Abscission-accelerating Substance in Senescent Leaves

Van Steveninck[1], in a recent communication describing abscission-accelerators from lupins, has suggested a similarity of one of these substances to the abscission-accelerating factor discovered in senescent leaves[2], and attributes to me the statement that the latter substance is not a sugar, amino-acid, purine or pyrimidine. In fact, in the paper in question[2] it is stated that the abscission-accelerator in senescent leaves was "so far unidentified chemically, but does not appear to be any of the more common sugars, amino-acids, purines or pyrimidines".

For clearness, it might be added that using bean explants for the bioassay, and testing a wide range of concentrations, no abscission-accelerating activity has been found for glucose, fructose, sucrose, glycine, aspartic and glutamic acids, L-valine, L-histidine, L-leucine, L-tyrosine, cysteine, methionine, adenine, guanine, xanthine, hypoxanthine or uracil.

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PHYSIOLOGY

Ester Sulphate Pattern of Rabbit Bile

Isselbacher and McCarthy[1] have recently reported excretion of a sulphate conjugate of bilirubin in the bile of rats. Using paper chromatography and autoradiography of diazotized bile from rats injected with sulphate labelled with sulphur-35, they demonstrated the presence of a radioactive zone in the area of the polar azo pigment.

A series of systematic screening studies on the ester sulphate pattern of different body fluids has recently been started at our laboratory[2,3]. A brief account is given in the following of some observations made in this connexion on the occurrence of ester sulphates in rabbit bile.

Four adult rabbits with an average weight of 2·5 kgm. were used. Doses of 5–10 mc. of radioactive sulphate were injected into the marginal vein of the ear. The rabbits (which were used for other studies as well) were kept starving in metabolic cages for 24 hr. after the injection. They were then killed by insufflation of air into the ear vein. The gall-bladders were removed, the bile emptied into test-tubes, and kept in the deep-freeze unit until used.

Of the different samples of bile obtained, 5 and 25 μl. were subjected without any pretreatment to two-dimensional paper chromatography according to Datta, Dent and Harris[4]. The following solvents were used: (1) Phenol–water (400 gm. + 100 gm.). A beaker containing concentrated ammonia was placed in the chromatographic tank. (2) Butanol–2 *N* ammonia (250 ml. + 250 ml.).

After drying the papers in a stream of hot air from an electric hair-drying fan, the chromatograms were subjected to autoradiography on Gevaert 'Curix' X-ray film, exposed for one week in a wooden screw-press and developed with *G*150.

Hydrolysing experiments with hydrochloric acid and sodium hydroxide were performed on two of the samples, as follows. To 10-μl. portions of the bile in small test-tubes, 90 μl. of distilled water, 0·1 or 0·5 *N* hydrochloric acid or sodium hydroxide, respectively, were added. The tubes were sealed, and heated in a boiling water-bath for 15, 30 or 60 min. After cooling, the tubes were opened and the solutions evaporated to dryness in an exsiccator. The residues were dissolved in 10 μl. of water, and 5-μl. portions of these solutions were subjected to combined chromato-autoradiography as previously described.

A typical result of this study is presented in Fig. 1. All biles so far investigated showed the same type of pattern of radioactive spots on the autoradiograms. In addition to the occurrence of some radioactivity at the starting point of the chromatogram (1), corresponding to labelled material which did not move in either of the solvents used, and the distinct spot of inorganic sulphate (2), at least six other compounds labelled with sulphur-35 were visualized (201–206). Most of these spots were fairly resistant to alkaline hydrolysis (0·5 *N* sodium hydroxide for 60 min. at 100° C.), since only minor changes in the pattern occurred under these conditions.

Heating in hydrochloric acid, on the other hand, destroyed the whole pattern. Thus, after heating in 0·5 *N* hydrochloric acid for 15 min. at 100° C., all the 201–206 spots vanished, and a marked increase in the inorganic sulphate spot took place.

Although none of the 201–206 spots has as yet been identified, it appears that a fairly large number

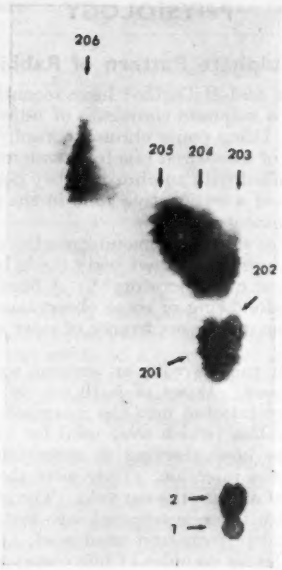

Fig. 1. Chromato-autoradiogram of 5 μl. of rabbit bile 24 hr. after injection of radioactive sulphate. Solvents: Phenol–water; butanol–ammonia. 1, Starting point; 2, inorganic sulphate; 201–206, unidentified compounds labelled with sulphur-35

of ester sulphates are excreted in the bile. Since no characteristic differences were found in this respect between the four animals studied under basic conditions, it is suggested that a characteristic, more or less constant ester sulphate pattern exists in rabbit bile.

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Site and Mode of Trehalose Biosynthesis in the Locust

The disaccharide trehalose was first identified as an important constituent of insect hæmolymph by Wyatt and Kalf[1] using silkmoth pupæ, and it has since been found in other insect species and in nematodes[2]. Howden and Kilby[3] showed that trehalose may occur in concentrations up to 2 per cent in the hæmolymph of the desert locust, *Schistocerca gregaria* Forsk., and isolated a crystalline sample from this source. Work with the migratory locust, *Locusta migratoria*[4], and the blowfly, *Phormia regina*[5], has shown that the concentration of trehalose falls sharply during flight, and it therefore appears that this sugar is an important soluble carbohydrate and energy reserve in insects. Treherne[6] has shown that radioactive glucose introduced into the gut of *Schistocerca* rapidly gives rise to the appearance of radioactive trehalose in the hæmolymph, but nothing has been known hitherto as to the site or mode of formation of trehalose from glucose.

We have now shown that locust fat body is an important site of trehalose biosynthesis. Generally labelled D-glucose-^{14}C was incubated with fat-body tissue from *Schistocerca* (fifth instar) and the products examined by paper chromatography. A significant radioactive peak was found corresponding to the trehalose spot. Hæmolymph, leg muscle, fore, mid and hind gut tissues were also tested but found to be largely inactive in converting glucose into trehalose. The clear supernatant fraction obtained by centrifugation of an extract of homogenized and freeze-dried fat-body tissue from adult locusts was also active. After dialysis, considerable enhancement of activity was obtained by adding adenosine triphosphate (ATP) and uridine diphosphate glucose (UDPG).

Table 1

Reaction mixture	Counts per min. for trehalose spot	Counts per min. for glucose spot
Dialysed enzyme + glucose + ATP + UDPG	818	18
Dialysed enzyme + glucose + ATP	144	27
Dialysed enzyme + glucose + UDPG	324	358

Small amounts of radioactivity appeared in other peaks, but these products have not yet been identified. In another experiment, the count for the trehalose spot rose from 38 to 953 c.p.m. on adding uridine diphosphate glucose to the system containing adenosine triphosphate.

The identity of the radioactive trehalose was confirmed by the following methods. It was isolated by paper chromatography and eluted, mixed with authentic trehalose and the mixture developed on paper chromatograms using four different solvents. Radioautography of the chromatograms showed that in all cases the radioactive spots were absolutely identical in shape and position with those due to trehalose on the chromatograms, detected by Trevelyan's silver nitrate method[7]. In another experiment, the same mixture was incubated with a trehalase preparation and it was found that the rate of appearance of reducing sugar was closely paralleled by the rate of appearance of radioactive glucose and the corresponding disappearance of radioactive trehalose. The figures in Table 1 show that both adenosine triphosphate and uridine diphosphate glucose are required. In the absence of added adenosine triphosphate, considerable amounts of free glucose remain, while in the absence of uridine diphosphate glucose most of the labelled glucose is converted into products other than trehalose. Since the uridine diphosphate glucose was present in substrate amounts, the requirement for adenosine triphosphate indicates that trehalose biosynthesis occurs through phosphorylated intermediates. Cabib and Leloir[8] have shown that yeast extracts convert glucose-6-phosphate into trehalose phosphate in the presence of uridine diphosphate glucose, and it appears probable that a similar pathway may occur in insects and that the trehalose phosphate formed is hydrolysed by a phosphatase to free trehalose. This point is now being considered.

A full account of this work will be published elsewhere. We are indebted to the Anti-Locust

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Iodine-131 Clearance-rates as an Indication of the Blood Supply of Bone

WE have described[1] the use of sodium-24 clearance studies in the experimental and clinical determination of bone vascularity. Sodium-24 has a half-life of only 15·06 hr. and in the United States is only available from Oakridge National Laboratory on one day of each week. Thus it is difficult to use it for clinical investigation if more than three half-lives have transpired since its removal from the pile. This led us to search for an isotope with a longer half-life that could be used for clearance studies. Iodine-131 is readily available in most large hospitals, where it is used for the investigation and treatment of thyroid diseases. The half-life of iodine-131 being 8·0 days, it is more suitable for clinical use throughout the week than is the short-lived sodium-24.

Iodine-131 emits beta-radiation of 0·6 MeV. and gamma photons with peaks of 0·367 and 0·080 MeV. These gamma photons can be counted from the body surface and thus the clearance-rate from an injected site can be followed. Douglas and Meneeley[2] have used iodine-131 to measure the blood flow in skin flaps in plastic surgical procedures. The potential clearance of iodine-131 should be greater than that of sodium-24 as the latter must arrive at an equilibrium with the sodium of local tissue fluid; this is not a factor with iodine.

Animal experiments were undertaken to determine the suitability of iodine-131 injected as the sodium salt for clearance studies in dog femoral heads. The procedure used was the same as described previously[1]. A dose of 5 μc. iodine-131 in 0·1 ml. as sodium iodide was used and good readings obtained from the hip joints. The metal syringe previously described was used. With refinements of technique the dose of 50–100 μc. sodium-24 previously used has also been reduced to 5–6 μc. for human use. The results are shown in Fig. 1 for twenty-eight hips in 21 dogs. The same three groups of clearance values emerged as had been found with the sodium-24 clearance studies. Thirteen femoral heads were vascular with clearances of 30·9–72·9 per cent in 10 min. Ten femoral heads were completely devascularized with clearances less than 9 per cent. Two of these showed a slow rise in count of a few per cent, presumably due to diffusion of the iodine-131 through the dead femoral head, thus coming nearer to the surface of the bone during the counting period.

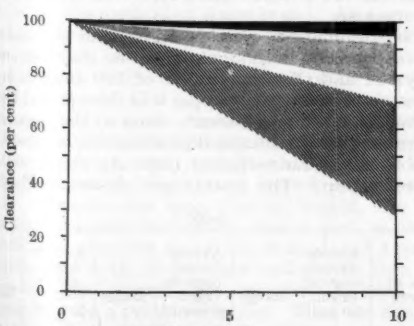

Fig. 1. Diagrammatic presentation of results on iodine-131 clearance of dog femoral heads. Black area shows avascular heads with less than 5 per cent clearance; cross-hatched area shows partially devascularized heads; and the stippled area shows the clearance in normal vascular heads

From these preliminary results there seems no objection to the use of sodium iodide-131 for the determination of the blood supply of bone in human patients. The dose of 5 μc. is small and safe and allows easy surface counting with a scintillation probe containing a 2-in. thorium-activated sodium iodide crystal. Uptake of iodine-131 by the thyroid may be prevented by pre-operative administration of iodides to the patient. Excretion of the injected sodium iodide-131 will then take place rapidly through the kidneys, thus ridding the body of the radioactive salt.

Our thanks are due to Dr. Campbell Moses, jun., under whose licence this work was performed; to Dr. Paul M. Meadows, for advice; to Mrs. Mary Grebner and Miss Patricia Orlic, for assistance; and to the U.S. Public Health Service, for grant No. 1625.

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Aqueous Humour of the Hippopotamus

THE opportunity recently arose to analyse the eye fluids of the hippopotamus (*Hippopotamus amphibius*). Specimens were chosen for analysis only from animals that had been killed instantaneously, and whose ocular fluids could be removed within a couple of minutes of death. Simultaneously, arterial blood was collected anaerobically from a suitably placed bullet wound. The average volume of fluid in the anterior chamber of the eye was 1 ml.

The fluids were analysed for potassium with a flame photometer, for total carbon dioxide by Conway's microdiffusion method, for chloride by the method of Schales and Schales. Total plasma proteins were estimated by van Slyke's copper sulphate method and corrections for the total solids of the fluids were made, so as to allow the ionic constituents to be expressed as m.moles/kgm. water. The figures in Table 1 were obtained.

The figures for carbon dioxide and chloride are in keeping with those found by Davson and Luck[1] in other animals with eyes of this size and proportion. (Average weight of globe 18·0 ± 1·8 gm. (*S.E.*) average weight of lens 0·95 ± 0·05 gm., from 4 hippopotamuses). The ratios, however, for potassium in the aqueous water/potassium in plasma water are,

Table 1

Animal No.	Aqueous	Plasma	Aqueous/Plasma
Potassium concentrations (m.moles/kgm. water)			
1	5·0	11·9	0·42
2	5·4	9·0	0·60
3	5·2	8·6	0·60
4*	8·5	8·3	1·02
Total carbon dioxide concentrations (m.moles/kgm. water)			
5	34·5	36·5	0·95
6	30·7	37·9	0·81
7	27·3	37·0	0·74
Chloride concentrations (m.moles/kgm. water)			
5	116	112	1·01
6	119	107	1·11
7	128	113	1·13

* This animal's aqueous humour clotted on standing, which only occurs under abnormal conditions of aqueous humour formation, resulting in an increased permeability of the blood–aqueous barrier.

with the exception of the fourth animal in this series, quite different from those found in other species[2].

To ensure that this distribution was not attributable to artefacts in the flame photometric analysis of fluids containing protein (8·7–10·2 gm. protein/100 ml. blood in this species), aqueous humour was dialysed against plasma from the same animal; the ratio after dialysis rose to 0·97.

The further possibility that the ratio is spurious and caused by the delay between collection and centrifuging the blood in the field, with a consequent rise in plasma potassium, is made unlikely by the high concentration of potassium found in the plasmoid aqueous of animal No. 4.

The main interest in this study lies in the observed potassium distribution.

Comparative studies of plasma, aqueous humour and the cerebrospinal fluid in several mammalian species have revealed so many similarities between the ionic composition of the aqueous humour and the cerebrospinal fluid that it has been postulated that the two fluids are formed by closely similar processes[3].

The cerebrospinal fluid varies less from species to species than does the aqueous humour; this depends perhaps on the greater variety of tissues in the eye, compared with that of the central nervous system, and the species variation in the relative size of these different components.

In all mammals hitherto examined, however, there has been one consistent difference in the ionic composition of the two fluids. The cerebrospinal fluid always contains markedly less potassium than the plasma; the ratio concentration of potassium in cerebrospinal fluid water/concentration of potassium in plasma water is of the order[4] of 0·5. The equivalent ratio for the aqueous humour is nearer unity and conforms more closely to the expected ratio for a dialysate of plasma. The ionic distributions, including that of potassium in the hippopotamus's aqueous humour are similar to those of the cerebrospinal fluid in most animals and appear to lend some support to the conception that the two fluids are formed by similar mechanisms.

Why the capacity to restrict the entry of potassium into the aqueous humour should be revealed in this species is a matter for speculation. The phenomenon may, however, be related to the unusually high concentration of potassium in the plasma; it is nearly twice that of most other animals. Davson[3] has postulated that the presence of a low concentration of potassium in the fluid around nerve cells in the central nervous system serves to stabilize the neuronal resting potentials. Perhaps a similar mechanism becomes necessary also in the eye (especially the retina) in the face of an unusually high level of plasma potassium.

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Iron Content in the Serum of Cows with Hypocupræmia

Disturbances in the health of cattle accompanied by a drop in the copper-level in the blood have been observed in several countries. Sjollema[1] was the first to show that loss of appetite, anæmia, deficiency in milk output, and difficulties in breeding occurred simultaneously with a drop in the copper-level. Hypocupræmia in cattle has been found in certain areas of Poland[2]. Some investigators believe that anæmia does not occur in cases of hypocupræmia[3]. Generally, however, the metabolism of iron and of copper are believed to be interdependent[4]. Lahey *et al.*[5] noticed that the iron content in the plasma of young pigs, which were given no copper in their food, was very low. So far as I know the iron content in the serum of cows with hypocupræmia has not yet been investigated, although the hæmoglobin content has. An apparent decrease in the hæmoglobin and erythrocytes in cattle during hypocupræmia has been noticed in our studies hitherto. It must, however, be admitted that in some cases we found no anæmia.

In the present work the iron content in the serum of cows with hypocupræmia has been determined. I wished to confirm that a drop in the copper-level in the blood influences iron metabolism in cattle. It is assumed that the iron and hæmoglobin contents in the serum are a valid indicator of the iron stock in the organism.

The examinations were performed on the blood of the cattle from individual farms in the districts of Białystok and Olsztyn. In 67 of 120 animals hypocupræmia was found. Copper was determined by the method of Eden and Green[6]. Iron in the serum was determined by the standard photometric method[7]. 45 cows from the Zootechnical Institute were used as a control group. The results are shown in Table 1.

Table 1

No. of cows	Average copper content (mgm. per cent)	Range	Average iron content (mgm. per cent)	Range	Average hæmoglobin content (gm. per cent)	Range
45 (controls)	98·8	79·7–135·0	181	135–215	11·4	8·5–13·3
67	49·7	8·6–75·8	126	86–215	8·2	5·9–10·3

These results obviously indicate that iron metabolism is affected by hypocupræmia. Detailed results will be published elsewhere.

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Effect of Protein-free Diet on the Vitamin A Storage in the Rat Liver

SEVERAL workers[1–4] have reported that diets low in protein reduced the storage of vitamin A in the liver and increased the rate at which stored vitamin A was depleted. On the basis of such data, a conclusion was drawn by investigators that protein is a necessary dietary constituent for normal storage and utilization of vitamin A. The work described here was designed to test the validity of the former hypothesis by comparing hepatic vitamin A storage in young rats fed an 18 per cent casein diet and in animals fed a protein-free diet under the conditions of controlled intake of vitamin A.

Six comparable pairs of weanling albino rats of the Yale strain with an average initial weight of 50 gm. were chosen for the study. One member of each pair was fed a protein-free diet, while the other member was given an 18 per cent 'vitamin-free' casein diet for a period of 3 weeks. Each animal was kept in a separate cage and was allowed to eat and drink *ad libitum*. The basal protein-free diet was comparable in composition to that of Rechcigl, Loosli and Williams[5] with the exception of the vitamin mixture. The vitamins used in this study were supplied in the form of *GBI* B Complex Dry Mix (purchased from General Biochemicals, Inc.) supplemented with α-tocopherol and vitamin D. Vitamin A was given orally to each rat every 48 hr. in the form of vitamin A acetate at a level of 30 I.U. Following a 3-week experimental period, the animals were killed and their livers analysed for the vitamin A content by the method of Ames *et al.*[6]. As a control, vitamin A was also determined in the livers of two additional rats at the beginning of the experiment. The livers of these control animals were found to contain 14·9 and 17·1 μgm. vitamin A.

The results of the experiments are shown in Table 1. The animals which were fed a protein-free diet lost an average of 16 gm. body-weight while those fed the casein diet gained 72 gm. in a 3-week experimental period. Despite this large loss of weight, the rats kept on a protein-free ration stored just as much vitamin A in the liver as did the animals fed a ration supplemented with 18 per cent casein. In fact, the casein-fed rats stored less vitamin A than the animals kept on a protein-free diet. Thus the average liver vitamin A content of the former group was 54·7 μgm. and that of the latter 96·1 μgm. In view of the considerable difference between the liver weights of the two groups it was of interest to compare the vitamin A content when expressed per unit of weight. The casein-fed rats contained an average of 9·3 μgm. vitamin A/gm. liver whereas the rats which were kept on a regimen devoid of any protein stored 71·2 μgm./gm. liver. The lower vitamin A value in the former group can be possibly explained by greater requirement of vitamin A for the purposes of rapid growth.

Table 1. GROWTH AND LIVER VITAMIN A STORAGE OF RATS FED 18 PER CENT CASEIN DIET AND PROTEIN-FREE DIET

Pair No. and sex	Protein-free		18 per cent casein	
	Weight gain (gm./3 weeks)	Vitamin A (μgm./liver)	Weight gain (gm./3 weeks)	Vitamin A (μgm./liver)
1 ♀	−13	103·2	70	64·4
2 ♀	−13	107·0	56	54·1
3 ♂	−16	75·0	83	39·6
4 ♂	−15	91·2	71	44·0
5 ♂	−19	94·1	70	47·3
6 ♂	−20	106·3	83	35·5
Average	−16	96·1	72	54·7

These results clearly demonstrate that under the given experimental conditions the rats fed a diet lacking in protein were able to store large amounts of preformed vitamin A in their livers, suggesting that protein is not absolutely essential for this process. This finding is supported by a recent observation of Arnrich and Pederson[7] that the level of dietary protein has no effect on vitamin A storage in the liver.

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Bioassay of Sheep Anterior Pituitary Glands

A HIGHLY significant seasonal variation in frequency of twin ovulations in Merino ewes was observed by Radford[1]. In order to determine whether this was correlated with seasonal variation in pituitary gonadotrophin content the surviving ewes from Radford's experiment were later killed—16 in mid-summer (January–February 1958) and 11 in mid-winter (June–July 1958). Each ewe was killed 14 days after œstrus.

From examination of the corpora lutea present in the ovaries at slaughter it was determined that seven of the 16 ewes in January–February, and eight of the 11 ewes in June–July had shed two ova at the recorded œstrus. The pituitary glands were removed, trimmed, deep frozen immediately after slaughter, and stored at −17° C. In October 1958, each gland was homogenized with 3 ml. distilled water. 1 ml. of a buffer (sodium borate, 0·05 ionic strength; sodium chloride, 0·45 ionic strength; *p*H 8·8) was then added to each homogenate. After

Table 1. Analysis of Variance. The Degrees of Freedom (D.F.) for Error (Within-Group Variance) are reduced by Five, comprising One for Regression of Response on Body-Weight and Four for Missing Plots

Source of variation	D.F.	Mean square
Slope	1	6,790*
Pituitary glands		
Between groups†	3	160
Within groups	21	358*
Interaction	24	93
Error	45	62

* $P < 0.001$.

† Groups consisting of ewes which had shed one or two eggs at the recorded œstrus, at the two slaughter times January–February or June–July.

1½ hr. extraction they were centrifuged and the supernatants freeze-dried. All steps were carried out at 0° C. The resultant powders were dissolved, each in 1·0 ml. distilled water, and the extracts were assayed simultaneously, using the immature mouse uterine weight assay[2]. Pairs of mice were injected subcutaneously with 0·3 ml. or 0·1 ml. per mouse and killed 44 hr. later. Mouse uterine and body-weights were recorded at autopsy and the data, after log transformation, were submitted to analysis of variance using the pair totals corrected for concomitant variation due to body-weight differences (Table 1). The results for two sheep were incomplete, due to the responses at the lower level being minimal. However, the pair totals in these cases were treated as missing plots with the appropriate reduction in degrees of freedom for error.

The slopes of the log dose – log response lines were homogeneous (mean slope, $b = 34{\cdot}5 \pm 10{\cdot}8$) and the mean responses for each pituitary gland differed significantly from sheep to sheep. There were no significant differences between the mean responses of the four groups of sheep.

The following conclusions seem warranted from the results.

There were no appreciable seasonal differences in gonadotrophin content of the glands in this experiment. Indeed, the lack of any difference between ewes which had shed one or two ova at the one time of the year, and the variability between individual sheep suggest that seasonal differences would have to be large to be observed. It is not known to what extent, if any, the different periods of storage at −17° C. contributed to this result. The weights of the frozen pituitary glands or body-weights of the sheep did not contribute to the variability between sheep since the correlations between response and pituitary weight (0·06) and response and body-weight (0·11) were non-significant.

The mouse uterine weight response has been shown to give satisfactory results and should find wider application in examining individual pituitary glands for gonadotrophin content. This is important since recent work by Lamond and Claringbold[3] has shown that numerous gonadotrophins elicit similar joint action in uterine responses, thus providing a uniform basis for interpretation of pituitary–gonad studies of the type described in this communication.

There is no evidence to suggest that the yield of gonadotrophin could be much increased by a different extraction procedure. However, if this could be done it would greatly increase precision of the assays by enabling the use of a greater number of mice. A minimum of eight mice per gland would be needed to allow satisfactory potency estimates of individual glands relative to a standard and if this were achieved it would make possible comparisons between different laboratories and between different times in the same laboratory.

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Response of Rice to Small Differences in Length of Day

Dore[1] has recently reported the response of a Malayan rice, an 'indica' variety of *Oryza sativa* L., to small differences in photoperiod. I have obtained similar results with West African upland cultivated rices, varieties of *Oryza sativa* L. and *Oryza glaberrima* Steud. The latter is the main indigenous rice cultivated in Northern Nigeria. Monthly sowings (May to October) of two varieties of *O. glaberrima* in Ibadan—

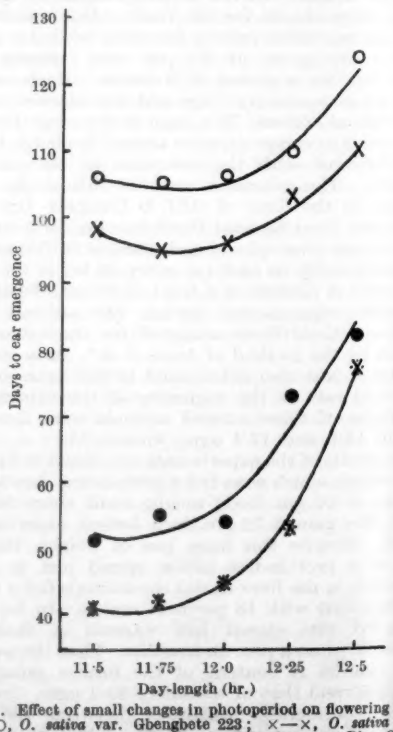

Fig. 1. Effect of small changes in photoperiod on flowering time. ○—○, *O. sativa* var. Gbengbete 223; ×—×, *O. sativa* var. Nagalawa Red Husk; ●—●, *O. glaberrima* var. Biya Gero; ✱—✱, *O. glaberrima* var. Ba Yawuri

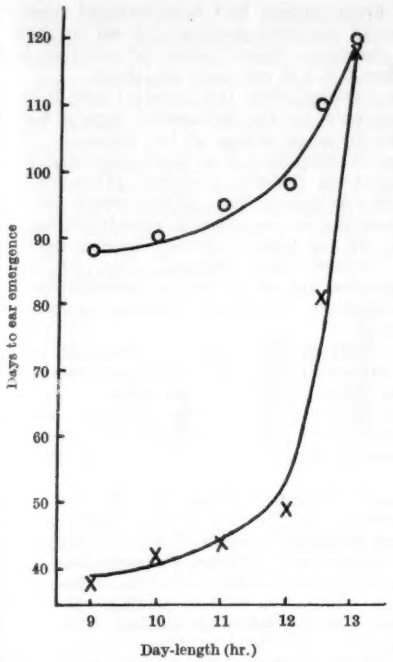

Fig. 2. Effect of photoperiod on flowering time. ○—○, *O. sativa* var. Ngalawa Red Husk; ×—×, *O. glaberrima* var. Ba Yawuri

latitude 7° 26′ N.—showed marked variation in time to ear emergence from sowing date, the later sowings flowering earlier. The time between sunrise and sunset at Ibadan varies from 11 hr. 40 min. in December to 12 hr. 33 min. in June.

Experiments in which the plants were given constant day-lengths, controlled by time switches, of a range similar to the natural photoperiods and differing by 15 min., showed that the field behaviour could be explained by the photoperiodic response under experimental conditions. For comparison the experimental studies were extended to two varieties of *Oryza sativa* L. cultivated in Sierra Leone. Apical bud dissections carried out at regular intervals showed that the time from inflorescence initiation to emergence did not vary significantly between the day-length treatments. The day-length effect on inflorescence initiation therefore parallels that on emergence. Fig. 1 shows for four rice varieties the curvilinear relationship between the time to ear emergence and photoperiod.

The varieties of *O. glaberrima* are earlier and more sensitive than the *O. sativa* varieties, but both species show over the range of natural day-lengths a quantitative short-day response similar to that reported by Dore, although these West African rices appear to be less sensitive than the Malayan one.

From the shape of the curves shown in Fig. 1 it was expected that by decreasing the day-length below 11½ hr. the curves would rise again on the left, and it would thus be possible to define optimum photoperiods such as those reported for 'indica' varieties of *O. sativa* by Chandraratna[3]. This expectation was not fulfilled, as can be seen from Fig. 2, which gives the results of experiments with day-length treatments varying from 9 to 13 hr. There is no evidence of a lower limiting photoperiod. If there is an optimum it must be well below 9 hr., outside the range of natural day-lengths. For *O. glaberrima* var. Ba Yawuri a number of plants did not flower at the 13 hr. day-length during the period of the experiment. Thus the upper limiting photoperiod for this variety appears to be close to 13 hr.

In the experiments on the effect of small differences in day-length reported above, 15 min. differences were used because the time switches available could not measure smaller differences accurately. But it is clear from the response curves, particularly of the *O. glaberrima* varieties, that in the steep parts of the curves, day-lengths 12–12½ hr. in Fig. 1, still smaller differences in day-length would produce appreciable effects on flowering time. Previous evidence for the response of rice to small changes in day-length is provided by the work of Kuilman cited by Bünning[3]. I have reported similar responses for Nigerian plants other than rice[4]. Details of the experimental method used in the present work are as given in that paper.

I wish to thank Mr. R. Q. Craufurd of the West African Rice Research Station, Rokupr, Sierra Leone, for seeds of the varieties of *O. sativa*, and Mr. J. E. Y. Hardcastle of the Federal Rice Research Station, Badeggi, Nigeria, for seeds of the varieties of *O. glaberrima*.

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Utilization of Alcohol in Germinating Pea Seedlings

Recent communications reporting a stimulation of growth in algae[1,2] and in seedlings[3] caused by added ethanol solutions have prompted us to report our findings of the ability of pea seedlings to oxidize alcohol which had accumulated under anaerobic conditions.

After soaking dried Kelvedon Wonder pea seeds in water at 20° C. for 20 hr., 404 mgm. alcohol/100 gm. fresh weight had accumulated. The peas were then placed in moving air on moist filter paper at 25° C. After 24 hr. the alcohol content had fallen to 270 mgm. alcohol/100 gm. fresh weight and 76 mgm. after 46 hr., by which time the radicles had emerged.

To check that the loss was not due to the volatility of the alcohol, a similar 100-gm. batch of peas was placed in a closed container through which an air-stream circulated. The outflowing gas-stream was bubbled through two absorption tubes containing concentrated sulphuric acid. When the alcohol content of the peas had fallen from 432 mgm./100 gm. fresh weight to 19 mgm./100 gm. fresh weight, only 22 mgm. of alcohol were recovered from the acid traps. A similar fall in alcohol content occurred when the peas were allowed to germinate under sterile conditions.

Acceleration of the loss of alcohol was caused by splitting or by complete removal of the seed coat. Thus cotyledons with 368 mgm. alcohol/100 gm. fresh weight contained 55 mgm. after 24 hr. at 25° C. The rate of carbon dioxide output and of oxygen uptake

increased rapidly during the initial stages of the loss of alcohol, decreasing with time as the alcohol content was depleted. However, the stimulation in carbon dioxide output only accounted for the disappearance of about 25 per cent of the alcohol. The respiratory quotient during this period equalled 0·5.

Preliminary examination of extracts of the peas during germination have shown temporary increases in acetaldehyde content associated with the disappearance of the alcohol and also, as shown by paper chromatography, increases in acetic and citric acids.

In this tissue there is, therefore, evidence that alcohol accumulated under anaerobic conditions can be metabolized under aerobic conditions, and experiments are in progress to elucidate these problems further.

One of us (E. A. C.) is the holder of a research studentship awarded by the Department of Scientific and Industrial Research, for which grateful acknowledgment is made.

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Effects of Heat and Loss of Moisture on the Dormancy of Wheat, and some Interactions with 'Mergamma D'

A previous communication[1] described the action of oven treatment at 38° C. in overcoming dormancy of barley without loss of moisture. Further experiments have shown that wheat does not respond in the same manner. Oven treatment in polythene appears to have no effect, and with loss of moisture the dormancy may increase.

The following results were obtained with Cappelle Desprez Wheat, ref. *A*101, approximately three weeks after harvesting (moisture content 17·5 per cent) (Table 1).

Table 1

Treatment	Control *R*⁰	Refrigeration	38° C. dried		38° C. polythene	
Duration of treatment	2 days	3 days	Overnight	2 days	Overnight	2 days
Germination at six days (per cent)	46	98	34	34	51	51

Peko wheat, ref. 2019, treated with mercury/BHC seed dressing ('Mergamma *D*') behaved similarly, although the seedlings showed typical signs of stunting (Table 2).

Table 2

Dormancy treatment	Peko wheat (ref. 2019)		2019 dried	
	Non-dressed	Dressed	Non-dressed	Dressed
None	83	76	86	87
Refrigeration	86	90	89	93
Oven-polythene	—	75	—	—
Oven-dried	—	67	—	73

The dried portion had been reduced from 19 per cent to 16 per cent moisture by an 'in-sack' drier before dressing. When tested, all samples had lost a further 0·5–1·0 per cent moisture.

It is evident that the reduced germination was due not only to the laboratory drying treatment, but also to some action of the dressing. This enhancing of dormancy has been suspected for some time without definite evidence (Thomson, J. R., personal communication). When tested immediately after dressing, this sample gave the following results: control, 72 per cent; dressed normal rate, 59 per cent; dressed twice normal rate, 24 per cent. Refrigeration led to maximum germination in each case, although increased dressing gave increased stunting.

Reduction in the degree of stunting of dressed wheat can result from oven treatment with or without drying. Sometimes this is manifest as a mere $\frac{1}{8}$-in. increase in root-length. Other samples show greater response; a root-length of $\frac{3}{4}$ in. becoming $1\frac{1}{2}$ in. in the treated sample, as occurred with Peko wheat 2019.

Dressed barley responds in the same manner. One sample of Proctor tested immediately after dressing produced roots of about 1 in. long, but when oven treated (in polythene) the roots were so similar to the non-dressed control that the differences would not have noticed in routine testing. Such a strong response has not yet been noticed with any wheat samples.

These observations may be of increasing interest in view of the suggestion that seed be tested for germination under the Seeds Act after the application of dressings[2].

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Effect of Pyrimidine Deoxyribonucleotides on the Regeneration of Bone-Marrow in Irradiated Mice

The effect of several nucleotides and nucleosides on the survival and peripheral blood-count of irradiated mice was studied in our previous experiments[1]. The subject of this communication is the mitotic index in bone-marrow and deoxyribonucleic acid synthesis in the spleen in mice after irradiation and administration of pyrimidine deoxyribonucleotides.

Female mice of strain *H*, weighing 20–25 gm., were subjected to total-body irradiation at a dose of 500 r.; 0·1 mgm./25 gm. body-weight deoxycytidylic acid and 2 mgm./25 gm. thymidylic acid as the calcium salt were injected 24 hr. after irradiation. The corresponding nucleosides were injected in equimolar concentration. The mitotic index was determined before irradiation and on the fourth, seventh and tenth days thereafter; six animals of each group were used at each interval and three such experiments were performed with both cytidine and thymidine derivatives. The bone-marrow was stained by the Feulgen method and 5,000–10,000 nucleated cells were counted from the femur of each animal. The rate of deoxyribonucleic acid synthesis was determ-

ined 2 hr. after injection of phosphate-32. The deoxyribonucleic acid phosphorus from the spleen was isolated by Schmidt and Tannhauser's method.

Both deoxyribonucleotides in the given amount stimulated the regeneration of bone marrow in irradiated animals. The results were statistically significant on the fourth and seventh days after irradiation. On the tenth day and after injection of nucleosides, the differences were no longer significant. In Fig. 1 the effect of thymidine and thymidylic acid is shown, the mean value before irradiation being taken as 100 per cent. This corresponds to 11·3 mitoses/1,000 nucleated cells.

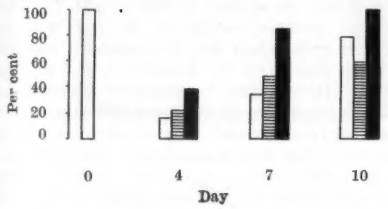

Fig. 1. The mitotic index in mice bone-marrow on the fourth, seventh and tenth day after irradiation and injection of saline (white); 2 mgm. calcium thymidylate (black); and 1·25 mgm. thymidine (shaded)

The number of chromosomal aberrations was somewhat higher in animals treated with deoxyribonucleotides than in the control group (on the fourth day 12 per cent compared with 11 per cent, on the seventh day 10 per cent and 5 per cent) but the differences were not statistically significant. In similar experiments with unirradiated mice the mitotic index was not influenced.

The changes in deoxyribonucleic acid synthesis were in the same sense as the changes in the mitotic index in bone-marrow. Results obtained on the seventh day after irradiation in mice injected with deoxycytidylic acid and deoxycytidine are given in Fig. 2.

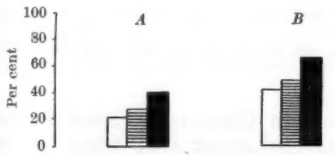

Fig. 2. The mitotic index in bone-marrow (*B*) and the rate of deoxyribonucleic acid synthesis in spleen (*A*) on the seventh day after irradiation and injection of saline (white); 0·1 mgm. deoxycytidylic acid (black); or 0·075 mgm. deoxycytidine (shaded)

The results thus agree with those arrived at in previous studies of the peripheral blood count. They show that pyrimidine deoxyribonucleotides hasten the regeneration of hæmatopoietic tissue after irradiation.

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Mixed Pigments in Colour Vision

Rushton[1] has recently suggested that the 'red' mechanism of the normal eye depends upon a mixture of two light-sensitive pigments, one of which is the same as that used for the 'green' mechanism. Marriage[2] has pointed out that addition of 'green' sensitivity to the red mechanism in this way will not affect the position on the chromaticity diagram of the red fundamental stimulus, but will affect that of the green fundamental stimulus, and will move it towards or away from the red fundamental point.

It is interesting to observe, therefore, that while the red and blue fundamental points have been determined by a number of different workers to a fair degree of consistency, efforts to locate the green point have always shown considerable scatter in the red–green direction; indeed, while some locations are at the green end of the diagram[3] others are in the opposite direction in the region well beyond the red end of the diagram[4]; and, while this abrupt difference is an artefact of the diagram itself, there is none the less a very considerable scatter.

It seems possible, then, that this scatter, which has for so long confounded efforts to locate the green fundamental point, may be caused in large part by variations in the relative amounts of the two pigments present in the red mechanism of the eye, the proportions of which could depend in various ways on the viewing conditions.

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Wealdstone, Middlesex.
Harrow, Feb. 2.

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BIOCHEMISTRY

Native Tobacco Mosaic Virus Protein of Molecular Weight 18,000

X-ray diffraction data on tobacco mosaic virus have been interpreted in terms of protein repeat units with a molecular weight of about 18,000 arranged in a helix[1]. Amino-acid analyses and end-group titrations[2] yield a similar minimal value but do not answer the question whether the ultimate molecular weight is 18,000 or some integral multiple of it. Thus far, the smallest native protein particles obtained by degradation of tobacco mosaic virus[3–5] have shown molecular weights of about 100,000. We have now been able to dissociate tobacco mosaic virus protein into undenatured particles with a sedimentation coefficient consistent with a molecular weight of 18,000.

Sedimentation studies were carried out in the synthetic boundary cell in a 'Spinco' ultracentrifuge at temperatures of 0–6° C. on protein prepared by treatment of tobacco mosaic virus at *p*H 10·3 and afterwards diluted to concentrations as low as 0·01 per cent with 0·05μ phosphate buffer at *p*H 7, with 0·1μ phosphate buffer at *p*H 6·5 or with 0·1μ borate buffer at *p*H 9. The centrifuge was operated at 59,780 r.p.m. and the boundary migration was followed by schlieren optics. As can be seen in Fig. 1, when the protein is diluted, the sedimentation-rate decreases from the value of about 4 Svedbergs frequently observed. The minimum value was 1·9

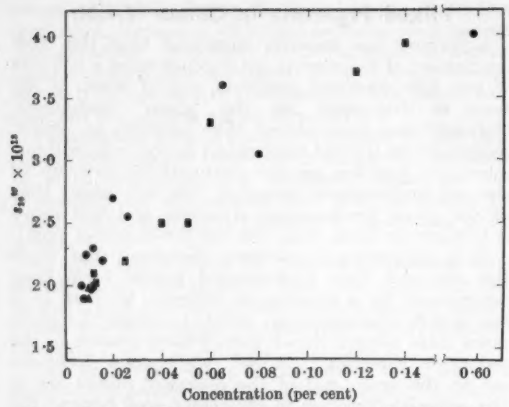

Fig. 1. Sedimentation coefficients of tobacco mosaic virus protein at various concentrations. ●, 0·10μ borate buffer, pH 9·0; ▲, 0·05μ phosphate buffer, pH 7·0; ■, 0·10μ phosphate buffer, pH 6·5

svedbergs. Control experiments were performed on Southern bean mosaic virus nucleoprotein diluted to the same low concentrations. Sedimentation coefficients agreed well with values extrapolated from determinations made at higher concentrations, thereby demonstrating that reliable measurements can be obtained by the method used.

If the X-ray diffraction data on the nucleoprotein of tobacco mosaic virus have been interpreted correctly, then the ultimate particle of the virus must be a truncated wedge with a maximum dimension or length of 70 A., with a thickness of 23 A. and with a maximum width of 34·8 A. It is virtually certain that the coefficient of friction lies between those of two elongated ellipsoids of revolution, both with semi-major axis of 70/2 A. and one with a semi-minor axis of 23/2 A. and the other with a semi-minor axis of 34·8/2 A. This type of reasoning, introduced by Lauffer and Szent-Györgyi[8], proved successful in interpreting the sedimentation behaviour of myosin and myosin fragments. The translational coefficient of friction, f, for randomly oriented elongated ellipsoids of revolution is given by the equation:

$$f = \frac{6\pi\eta b\sqrt{(1 - a^2/b^2)}}{\ln\left(\frac{1 + \sqrt{(1 - a^2/b^2)}}{a/b}\right)}$$

where η is the coefficient of viscosity, b is the semi-major axis and a is the semi-minor axis. The coefficients of friction in a medium having the viscosity of water at 20° C. for the smaller and for the larger ellipsoid are $3{\cdot}49 \times 10^{-8}$ and $4{\cdot}52 \times 10^{-8}$ c.g.s. units, respectively. By using the sedimentation formula:

$$s = \frac{M\,(1 - V\rho)}{Nf}$$

where s is the sedimentation coefficient corrected to water at 20° C., M is the molecular weight, N is Avogadro's number, V is the partial specific volume and ρ is the density of the medium, one can calculate the range of molecular weights consistent with a sedimentation coefficient of $1{\cdot}9 \times 10^{-13}$ c.g.s. units. The value of V was taken[4] to be 0·74 ml./gm. Molecular weights of 15,000 and 20,000 were obtained with the higher and with the lower friction coefficient, respectively. Since these values bracket 18,000, the sedimentation coefficient of 1·9 Svedbergs is concordant with the protein repeat unit postulated in the tobacco mosaic virus structure derived from X-ray diffraction studies. In a similar way, it can be shown that a sedimentation coefficient of 1·9 Svedbergs could not correspond to integral multiples of the 18,000 molecular weight. Comparable low molecular weights have been reported previously for the denatured protein of tobacco mosaic virus[7,8].

Several methods have been used to re-concentrate the diluted tobacco mosaic virus protein. The most successful involved dialysis against a 30 per cent aqueous solution of polyvinylpyrrolidone. Approximately ten-fold re-concentrations and recoveries of 50–70 per cent were obtained for material initially diluted in 0·05μ phosphate buffer at pH 7. The re-concentrated protein, adjusted to pH 6·5, polymerized into rods when the temperature was raised to 25° C., as described by Lauffer *et al.*[5] for the s_4 component. It was also reconstituted with tobacco mosaic virus nucleic acid into rod-like nucleoprotein particles. Polymerization can be obtained readily. Reconstitution has been completely successful in one experiment; attempts to achieve it under somewhat different conditions of pH and ionic strength have thus far failed. Therefore, the dissociated protein must have remained native.

The present work provides the first direct experimental evidence known to us for the existence of a native sub-unit of tobacco mosaic virus protein with a molecular weight agreeing with the value of 18,000 postulated in the interpretation of X-ray diffraction patterns.

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Differences in Chromatographic Patterns of Deoxyribonucleic Acid from Various Tissues

The constant deoxyribonucleic acid content per set of chromosomes[1,2] and the close similarity of average base composition of deoxyribonucleic acid[3] in various tissues in an animal species can be explained by assuming that the replication of all chromosomal deoxyribonucleic acid initially present in the fertilized ovum follows precisely the Watson–Crick model[4] during the ontogenesis. Recent observations of Bendich *et al.*[5], however, revealed that deoxyribonucleic acid from one animal source is heterogeneous and can be represented as a 'chromatographic profile' as fractionated on an 'Ecteola' cellulose column[6]. Such profiles are different from one tissue to another even in a single mammalian species. The most remarkable difference was found between rat kidney and rat brain. This observation is difficult to reconcile with the Watson–Crick replication model, and suggests a pronounced differentiation of deoxyribonucleic acid during ontogenesis. In repeat-

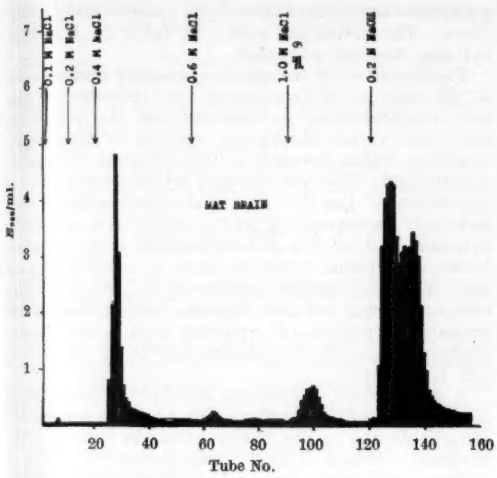

Fig. 1

ing the experiments of Bendich *et al.*, we have obtained a different result, which will be described below.

Twenty adult rats, each weighing about 200 gm., were killed by decapitation. Brain and kidney tissues were quickly removed and immersed in 0·14 *M* sodium chloride–0·01 *M* sodium citrate containing ice. Deoxyribonucleic acid was prepared in parallel from these two tissues by the method of Kay, Simmons and Dounce[7]. The procedure used in the chromatographic fractionation was essentially that described by Osawa and Sakaki[8].

Figs. 1 and 2 show the chromatographic patterns of these preparations. It is clear that no remarkable difference exists between deoxyribonucleic acid from brain and kidney with respect to chromatographic behaviour.

Similar fractionations were carried out on samples of deoxyribonucleic acid prepared from kidney, liver, appendix and testis of adult albino rabbits. In most of these experiments, except for testis, nucleohistone was first prepared according to Mirsky and Pollister[9], followed by the removal of proteins with 'Duponol' by the method of Kay *et al.*[7]. All deoxyribonucleic acids again showed similar patterns in so far as the conditions of preparation and chromatographic fractionation were kept constant. It was, however, found that the sample prepared from nucleohistone and that prepared by the original procedure of Kay *et al.*[7] gave somewhat different pictures. This suggests, as already pointed out by Bendich *et al.*[10], that the chromatographic 'profiles' are largely influenced by the methods of preparation. In any event, we could find no evidence of tissue specificity in this respect, even when the comparison was made on the deoxyribonucleic acids of rat kidney and rat brain, between which the existence of a remarkable difference of 'profiles' had been emphasized[5,11,12].

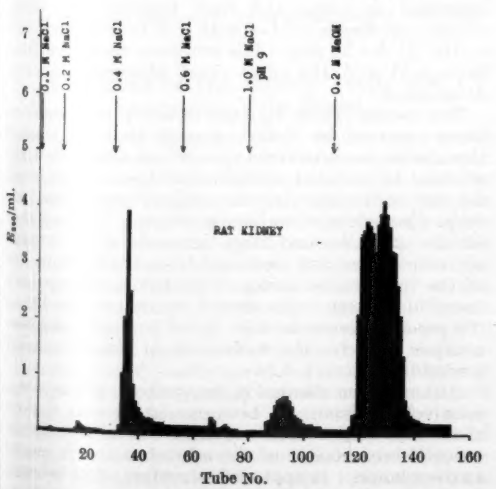

Fig. 2

Discrepancy between our results and those of Bendich *et al.* may be due in part to the different methods of preparation. In our opinion, a reliable procedure for deoxyribonucleic acid preparation applicable to all tissues should be established before any precise chromatographic comparison is attempted.

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Bromination of Nucleic Acids and their Derivatives

RECENT communications on this subject[1–3] have prompted us to report some results of observations which include an extension of work previously described by one of us[4,5].

Suzuki and Ito[1] have reported the effects of bromine on the ultra-violet absorption spectra of some purines, pyrimidines and nucleosides. There was almost complete elimination of the characteristic maxima in the absorption in the region 245–280 mμ, except for adenosine, which was practically unaffected by treatment with the strongest reagent used (1 drop of saturated bromine water to 3 ml. of 7×10^{-5} *M* nucleoside).

In the present investigation purines, pyrimidines, nucleosides and nucleotides were treated as follows with bromine water at slightly greater concentrations than those used by previous workers.

A solution (10 ml.) of the substance (0·1 mgm.) in either distilled water or 0·1 *N* hydrochloric acid was treated at room temperature with saturated aqueous

Table 1. Effect of Bromination on the Ultra-violet Absorptio Spectra of Purines, Pyrimidines, Nucleosides and Nucleotides

Compound	Brominated in distilled water	Brominated in 0·1*N* hydrochloric acid
Adenine	Peak at 260 mμ eliminated	Peak at 262·5 mμ unchanged
Adenosine	Peak at 260 mμ unchanged	Peak at 257 mμ unchanged
Adenosine-3′-phosphate, -5′-phosphate, -5′-triphosphate; deoxyadenosine	Peak at 260 mμ slightly reduced	Peak at 257 mμ unchanged
Guanine; guanosine; guanosine-2′(3′)-phosphate	Peaks in the region 245–255 mμ and 275 mμ eliminated	
Cytosine; cytidine; cytidine-2′(3′)-phosphate; deoxycytidine-5′-phosphate	Peak at 267 or 270 mμ eliminated; new peak at 235 mμ	Peak at 275 or 280 mμ eliminated
*Iso*cytosine	Peak at 285 mμ eliminated	Peak at 257 mμ eliminated
Thymine; thymidine; thymidine-5′-phosphate	Peak at about 267 mμ eliminated	
Uracil; uridine; uridine-2′(3′)-phosphate	Peaks at 258 or 262 mμ eliminated	
4-Aminopyrimidine	Peak at 235 mμ almost eliminated	Peak at 245 mμ eliminated

bromine water (0·25 ml.). After 10 min. the bromine was removed by 10 min. vigorous aeration and the ultra-violet absorption spectra of the solutions measured. The results (given qualitatively in Table 1) were in agreement with those reported previously[1] and, in particular, the resistance of adenosine to the action of dilute aqueous bromine was confirmed. Deoxyadenosine and the phosphates of adenosine reacted very slightly with bromine.

The resistance of derivatives of adenine suggested that bromination might be used as a method for the specific degradation of nucleic acids. For this purpose deoxyribonucleic acid (DNA) was treated with bromine as follows:

The deoxyribonucleic acid of calf thymus, isolated by Marko and Butler's method[6] (25 mgm.), was dissolved in 25 ml. of acetate buffer (*p*H 6, ionic strength 0·1) and mixed with 12 ml. chloroform. A solution of bromine in chloroform (1·25 ml.; 10 mgm. bromine/ml.) was added and the solution shaken at 20° C. for 30 min. The mixture was then centrifuged, when a gel layer (not produced by the original deoxyribonucleic acid) was formed at the chloroform–water interface. This was due to the formation of an insoluble gel during the bromination of the deoxyribonucleic acid.

The aqueous and gel layers were combined and treated with ethanol (3 vol.). The precipitate so produced was only partly soluble in water so a suspension of the material was exhaustively dialysed and then freeze-dried to give a yellow solid, designated $BDNA_1$ (22 mgm.).

The deoxyribonucleic acid was also brominated at 2° instead of at 20° C. to give $BDNA_2$ (25 mgm.), and at 20° C., without including chloroform in the reaction mixture and using bromine dissolved in acetate buffer, to give $BDNA_3$ (25 mgm.). These samples were analysed by Dr. D. S. Letham, using formic acid hydrolysis and paper chromatographic separation and estimation of the purines and pyrimidines[7]. The results are shown in Table 2. 5-Methylcytosine was not estimated.

Table 2. Base Composition of Brominated Calf-Thymus Deoxyribonucleic Acid
(Moles of base per 4 atoms of phosphorus)

	Adenine	Thymine	Guanine	Cytosine
DNA	1·10	1·12	0·84	0·86
$BDNA_1$	1·00	0·25	0·12	0·18*
$BDNA_2$	0·95	0·72	0·40	0·49*
$BDNA_3$	0·91	0·60	0·22	0·35*

* Estimated as cytosine, but was probably a mixture.

The identities of the adenine, guanine and thymine in the samples of brominated deoxyribonucleic acid were established by comparison with the R_F values and ultra-violet absorption spectra of the corresponding bases present in the original deoxyribonucleic acid. The cytosine spot on chromatograms of hydrolyses of the brominated deoxyribonucleic acid, although corresponding in R_F value with authentic cytosine, had, in 0·1 *N* hydrochloric acid, an ultra-violet absorption spectrum with a broad flat peak with a poorly defined maximum at 280 mμ. This component was not investigated further, but it was probably a mixture of cytosine with a brominated product ($\varepsilon_{max.}$ of 5-bromocytidine is at 289 mμ at *p*H 7, ref. 8).

A satisfactory ultra-violet absorption spectrum of the brominated deoxyribonucleic acid was not readily obtainable due to the partly insoluble nature of the material. When $BDNA_1$ was dissolved in 0·1 *N* sodium hydroxide, however, and allowed to stand for 10 min. at 37° C. a drop in the absorption at 260 mμ of 53 per cent as compared with the original deoxyribonucleic acid was obtained. No further reduction in optical absorption occurred on standing at 37° C. for a further 48 hr. The alkali treatment also caused degradation of the molecule as shown by the fact that treatment with 0·1 *N* sodium hydroxide at 37° C. for 15 hr. caused 50 per cent of the material absorbing light at 260 mμ to become dialysable.

Since thymine derivatives were as readily attacked by bromine as were cytosine and guanine derivatives, the relative resistance of the thymine in the deoxyribonucleic acid was remarkable. It appeared possible that the hydrogen bonding of the thymine in deoxyribonucleic acid to the bromine-resistant adenine may have afforded protection to the thymine residues. Another explanation was that some of the thymine may have been regenerated by the acid hydrolysis used to determine the base composition of the brominated deoxyribonucleic acid. The second explanation was supported by the following results.

Derivatives of thymine, cytosine and uracil were treated in aqueous solution with bromine water as previously described. The solutions were next concentrated *in vacuo* and then treated with either 40 per cent formic acid or with 7 *N* hydrochloric acid at 100° C. for 30 min. The solutions were then freed from acid and the ultra-violet absorption spectra determined.

The results (Table 3), some of which are similar to those reported by Cohn[2], suggest that brominated thymine is converted into thymine on acid hydrolysis, whereas brominated cytosine and brominated uracil are not converted into the original bases, but into other ultra-violet absorbing products. The fact that all the thymine and large amounts of a cytosine derivative were not recovered from the hydrolysates of the brominated deoxyribonucleic acid may have been due to the more drastic hydrolysis conditions (98 per cent formic acid at 175° C.) used for the base analysis than for the hydrolysis of the brominated pyrimidines.

Although the adenine in deoxyribonucleic acid was relatively resistant to bromination, it was obvious that considerable destruction of the adenine would occur if bromination of the other bases were carried to completion. It appeared, therefore, that bromine was not so selective as was potassium permanganate

Table 3. ACTION OF ACID ON THE ULTRA-VIOLET ABSORPTION SPECTRA OF BROMINATED PYRIMIDINES

Brominated compound	Treatment at 100° C. for 30 min. with: 40 per cent formic acid	7 *N* hydrochloric acid
Thymine	Spectrum identical with that of the original thymine	
Thymidine-5′-phosphate	As for thymine*	—
Uracil	Peak at 275 mμ, 65 per cent of the height of that of uracil at 260 mμ	Peak at 275 mμ, 90 per cent of the height of that of uracil at 260 mμ
Cytosine	Peak at 277 mμ. Same absorption as that of cytosine at 267 mμ	—

* The solution of thymidine-5′-phosphate after bromination and treatment with formic acid was again treated with bromine water. The peak at 267 mμ was again eliminated.

at 37° C., a reagent, which, as has already been reported[9], oxidized almost completely the guanine, cytosine and thymine in deoxyribonucleic acid, but left 95 per cent of the adenine intact. The latter reagent is, therefore, superior to bromine for the determination of the distribution of adenine in deoxyribonucleic acid.

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Androgens in the Bovine Testis and Spermatic Vein Blood

BULL testis is the organ from which testosterone was first isolated nearly twenty-five years ago[1]. Information is still scarce, however, on the hormone content of this gland at various stages of the animal's development, nor is it known at what age androgenic steroids are first secreted by the gonads in appreciable amounts. Hooker[2] was able to demonstrate the presence of unidentified androgenic material in the testes of prepuberal calves by bioassay. Recent evidence, derived from the chemical analysis of seminal plasma and accessory secretions, indicates that already at the early age of 4–5 months a source of androgens must be present in bull calves, sufficient to induce specific secretory activity in the male accessory glands[3]. The present study was intended to supplement these observations by direct determination of androgenic steroids in the testicular tissue and the spermatic vein blood of the bull.

Material from 25 animals of both dairy and beef breeds, varying in age from 39 days to 17 years, was examined. The 'neutral ketonic fraction' separated from testicular lipid extracts was partially purified by a countercurrent distribution and resolved by paper chromatography in systems developed by Bush[4]. Compounds exhibiting the ultra-violet absorption curve of an α-unsaturated 3-oxosteroid were determined by their absorption at 240 mμ. Additional evidence on the identity of the extracted steroids was obtained by the examination of their absorption spectra in concentrated sulphuric acid and the study of the products formed by acetylation and oxidation or by treatment with Zimmermann's alkaline *m*-dinitrobenzene reagent; finally, purified material was submitted to infra-red spectral analysis. Blood samples were obtained from the spermatic vein of a number of animals and analysed by similar methods. The results were briefly as follows.

Both testosterone (17β-hydroxyandrost-4-en-3-one) and androstenedione (androst-4-en-3 : 17-dione) were identified as constituents of the bull testis at all stages of sexual development, and could be detected at an age as early as 39 days. Per unit weight of tissue, the combined content of the two steroids was not very different in the testes of very young calves (0·4–3 μgm./gm.) and those of fully grown bulls (1–6 μgm./gm.). However, whereas in the mature bull the major testicular androgen was testosterone, in the young calves the predominant steroid was identified as androstenedione. The ratio testosterone/androstenedione was greater than 15 in each of eight adult bulls, but never higher than 0·7 in the eleven calves less than 4 months old.

This pattern was clearly reflected in the steroid composition of the spermatic vein blood. Androstenedione predominated in the blood of 3 months old calves, testosterone in that of adult bulls, while an intermediate ratio of testosterone to androstenedione (approximately 3 : 1) obtained in 4–7 months old calves. Treatment of young male calves with human chorionic gonadotrophin increased both the rate of secretion of androstenedione and its concentration relative to testosterone in the spermatic vein blood. Thus, for example, 0·12 mgm. androstenedione and 0·03 mgm. testosterone were secreted per hr. in the untreated member of a pair of 3 months old monozygous twin calves, while in the other member of this pair, which had received gonadotrophin injections (2,000 I.U./48 hr.) for 7 weeks, the secretion-rate increased to 1·08 mgm. androstenedione and 0·04 mgm. testosterone/hr. By contrast, adult bulls responded to treatment with the trophic hormone with a marked and immediate increase in testosterone secretion. Small amounts of two further steroids were detected by paper chromatography in the spermatic vein blood of gonadotrophin-stimulated calves. Their R_F-values, absorption maxima and behaviour towards acetylating and oxidizing agents and the Zimmermann reagent were those of progesterone and 17α-hydroxyprogesterone (17α-hydroxypregn-4-en-3 : 20-dione).

An additional component was present in a number of extracts of spermatic vein blood collected from bull calves and was shown to be *epi*testosterone (17-α-hydroxyandrost-4-en-3-one). There was reason to believe, however, that this unusual steroid was not secreted as such by the testis, but was formed by the subsequent action of the blood on a substrate of testicular origin. When androstenedione was added to sterile blood (ox or sheep) and the mixture

incubated aerobically at 35° C., there occurred a rapid formation of *epi*testosterone, together with smaller amounts of testosterone. This phenomenon was not observed in plasma separated from corpuscles, nor in washed blood corpuscles resuspended in saline.

The present investigation has demonstrated by means of direct chemical determination of steroids that androgenic substances are secreted by the bovine testis into the blood stream already at a very early age. *In vitro* studies by Slaunwhite and Samuels[5] have indicated the following sequence of biosynthetic reactions in rat testicular tissue: Progesterone → 17α-hydroxyprogesterone → androstenedione → testosterone. Our results suggest that the conversion of androstenedione to testosterone may be a rate-limiting reaction in the elaboration of testosterone by the immature bovine testis. A transition to a secretion in which testosterone is predominant would seem to precede the appearance of pubertal changes in this species.

This study is now being extended to other species of farm animals, and in the adult ram, for example, both testosterone and androstenedione were shown to be present in the spermatic vein blood in proportions similar to those found in the bull.

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Acid Mucopolysaccharides of Normal Urine

The occurrence of at least one acid mucopolysaccharide in normal urine has repeatedly been reported[1–3]. It was found by various authors[1–3] to behave chromatographically and electrophoretically like chondroitin sulphate *A*. Separation and staining, however, were unsatisfactory.

We recently described[4] a convenient and highly specific staining method for acid mucopolysaccharide in which use was made of a 1 per cent solution of alcian blue (Gurr or Harleco) in a 9 : 1 mixture of acetic acid and water (5 min.), followed by alternate washings with acetic acid and tap water. The intensely blue acid mucopolysaccharide spots stand out on a pure white background, and as little as 0·5 μgm. of heparin or 2·0 μgm. of chondroitin sulphate *A* can be detected. Scanning allows quantitative estimations, since the uptake of dye appears to be proportional to the acid mucopolysaccharide concentration over a wide range. A correction factor is nevertheless required to allow for different specific dye uptakes by different acid mucopolysaccharides.

By using an ultrafiltration and dialysis method, to be described elsewhere, it was possible to concentrate normal urines up to 3,000 times without any denaturation of their colloids. Electrophoresis on Whatman No. 1 filter paper in a veronal–acetate buffer of *p*H 8·6 and ionic strength 0·1, using 3 V./cm. for 12 hr., resulted in very sharp separation of three different acid mucopolysaccharides, which migrated ahead of the albumin peak. The fastest and most abundant peak migrated about twice as fast as albumin, and at exactly the same speed as commercial chondroitin sulphate *A*. This is presumably the substance described by other authors[1–3]. The second peak, which was usually though not always smaller than the first, had a mobility of about 1·5 times greater than albumin. The third and smallest peak was about 1·1 times faster than albumin. None of these substances could be stained by protein dyes.

Fig. 1. Urinary acid mucopolysaccharides separated by electrophoresis at *p*H 8·6 and stained with alcian blue. The albumin(unstained) is indicated by arrows

All three appeared to have some anticoagulant activity of the heparin type, which casts considerable doubt on their identification as chondroitin sulphates *A* or *C*, which are known to be devoid of anticoagulant properties. On the other hand, commercial alpha-heparin samples ('Liquaemin', Roche) was found to migrate distinctly faster than the fastest urinary acid mucopolysaccharide peak.

The identification of these three substances must await further investigation, which is now in progress in our laboratory.

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Persistence of Cholesterol-4-^{14}C in the Central Nervous System

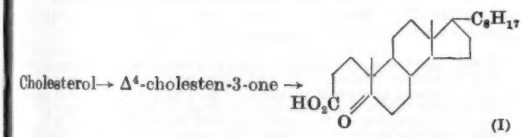
Recent work from this laboratory[1,2] has shown that once cholesterol-4-^{14}C is incorporated into the central nervous system of developing rabbits and chickens it remains with little change for more than a year. It seems likely that this radioactive cholesterol is incorporated into the myelin sheath, but there remains the possibility that once in the central nervous system the cholesterol undergoes internal turnover, being broken down and resynthesized *in situ*. This communication presents evidence to show that the radioactive carbon atom, even after 18 months, remains in its original position in the cholesterol molecule. In these experiments cholesterol extracted from the central nervous system with chloroform–methanol (2 : 1) was isolated by fractionation on an alumina column. The cholesterol was converted to cholestenone by an Oppenauer oxidation[3]. Next the radioactive cholestenone was ozonized

Table 1. LOCALIZATION OF RADIOACTIVITY IN THE CHOLESTEROL RING

Time after injection (days)	Dose given (μc.)	Specific activity (c.p.m./mgm. of cholesterol or its equivalent)			
		Crude extract	Cholesterol	Cholestenone	Keto-acid (I)
375 (rabbit)	5	45	47	35	1·8
502 (chicken)	3	22·9	23·4	14	0·96

A crude lipid extract in alcohol–ether (3 : 2) or chloroform–methanol (2 : 1) was obtained from the central nervous system of animals injected with cholesterol-4-^{14}C soon after birth. Pure cholesterol was obtained by recrystallization of cholesterol separated from the crude extract by column chromatography. Cholestenone and the keto-acid were prepared as described below.

and then oxidized with hydrogen peroxide by the method of Turner[4]. The keto-acid (I) obtained as a result of this elimination of a carbon atom at position 4 was purified and recrystallized. The melting point was in agreement with that reported in the literature[4,5]. Comparison of the radioactivity of the cholesterol with the radioactivity of the keto-acid (Table 1) shows that almost all the activity disappears on elimination of the 4-C atom. Furthermore, it was found that all the radioactivity in the original crude extract of the central nervous system was due to its content of radioactive cholesterol (Table 1). This latter result also suggests that the cholesterol molecule remains intact in the central nervous system for more than a year, for if the cholesterol-4-^{14}C had been degraded it would be anticipated that other radioactive lipids would be synthesized from the resultant fragments. These two groups of experiments, therefore, support the view that the cholesterol that persists in the central nervous system remains metabolically inert for more than a year.



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A Simplified Physico-chemical Method for Determination of Human Urinary Œstrogens

THE methods for estimating urinary œstrogens are open to criticism and are not easily applied as a routine in the laboratory because of their complexity. Our chief aim in the present investigation is to develop a reliable, practical and simplified method for studying the excretion of urinary œstrogens by patients with cancer of the breast.

100 ml. urine of 24-hr. sample was adjusted to *p*H 5 with concentrated sulphuric acid. 10 per cent by volume of acetate buffer was added, followed by 300 Fishman units of β-glucuronidase/ml. urine. This was incubated at 37° C. for five days[1]. After completion of hydrolysis, the urine was extracted four times with 100 ml. peroxide-free ethyl ether. The ether extract was washed with (*a*) saturated sodium carbonate solution, *p*H 10·5, (*b*) 2 *N* sodium hydroxide solution which was neutralized to *p*H 10 with 8 per cent sodium bicarbonate solution and shaken again with the ether extracts, (*c*) 8 per cent solution of sodium bicarbonate, (*d*) water[2]. The ether extract was evaporated to dryness and the residue dissolved in about 80 ml. toluene; this was extracted four times with 0·25 volume *N* sodium hydroxide and washed twice with 0·05 volume water. Neutral steroids remain in toluene layer. Alkaline extracts and washings were acidified to *p*H 9 with sulphuric acid (6 *N*) and extracted four times with 0·25 volume ether. This was evaporated and the residue was transferred to small storage bottles with methyl alcohol and evaporated to dryness at 60° C. Counter-current distribution in 50 per cent methanol, 50 per cent water (upper layer)/carbon tetrachloride (lower layer)[3] was then carried out for 24 transfers. Œstrogen extract was dissolved in 0·2 ml. ethanol and heated in a water-bath with 1 ml. 90 per cent sulphuric acid at 80° C. for 10 min. This was diluted with 4 ml. 65 per cent sulphuric acid and cooled in crushed ice for 30 min. Fluorescence was measured in a Farrand photofluorometer model *A* using Corning glass No. 3389 and No. 5113 as the lamp filter (436 mμ) with Nos. 3387 and 4308 and a 483 mμ interference filter as the photocell filter[4–6].

The specificity, precision and accuracy of the newly developed technique are shown in Table 1. These results were obtained by running a series of recovery experiments for the three major naturally occurring œstrogens.

Table 1. RECOVERY OF ŒSTRONE, ŒSTRADIOL-17β AND ŒSTRIOL ADDED TO 100 ML. OF NORMAL MALE URINE BEFORE HYDROLYSIS

Œstrogen used	Amount added (μgm.)	Percentage recovery	Partition coefficient*
Œstrone	100	85	3·4
	50	82	
Œstradiol-17β	100	91	2·1
	50	87	
Œstriol	100	93	15·3
	50	94	

* Between 50 per cent methanol and carbon tetrachloride.

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Effect of Drugs upon Components of Bacterial Cytoplasm

Ultracentrifugal analysis has shown that one of the main ribonucleoprotein components of bacterial cytoplasm is sensitive to alterations in the concentrations of certain salts present in the growth medium, or in the medium in which cells are suspended before they are disrupted[1–3]. This component sediments at about 40S. (uncorrected) and its breakdown within whole cells is favoured by lowering the concentration of magnesium ions or raising that of inorganic phosphate; ribonucleoprotein particles sedimenting at about 29 and 20S. are relatively insensitive to these extracellular changes in concentration.

It does not appear that the 40S. component plays any part in the metabolism of the cell which other ribonucleoprotein units of smaller molecular weight cannot share. For example, when bacteria were depleted of this component their ability to synthesize β-galactosidase was not impaired[4]. A connexion between bacterial cell-division and stability of the 40S. component is suggested by the requirement of both processes for magnesium ions. Accordingly, we examined cultures grown in the presence of 5 I.U. penicillin/ml., which stopped cell-division but allowed synthesis of cellular material to proceed, so that the whole culture eventually consisted of filamentous cells several times their normal length. However, no change was observed when schlieren diagrams were compared; the amount of 40S. component present in extracts from filamentous cells was the same as that from normal cells.

These results stand in contrast to those obtained for 'Chloromycetin' (chloramphenicol). *Escherichia coli* was grown in the medium containing peptone, glucose and inorganic phosphate as previously described[2] except that the concentration of magnesium sulphate was raised to 6·5 m*M* to avoid breakdown of the 40S. component at high cell populations[4]. During an incubation period of 150 min. five samples were removed at intervals from a control culture and, after centrifuging, the cells were disintegrated in bacterial presses[5] and five soluble cell-free extracts were obtained. The experiment was repeated using *E. coli* cells from the same overnight grown culture for inoculation but with addition of 5 μgm. of 'Chloromycetin'/ml. of growth medium; this caused a lag in both growth and cell-division, and no filamentous bacteria were observed. Ultracentrifugal analysis showed that this treatment with 'Chloromycetin' caused marked alterations in schlieren diagrams of extracts. Incubation with the drug for 30 min. resulted in a considerable increase in area of a peak sedimenting at 18S. and the appearance of a new peak at 14S.; both increased further during the lag period. In Fig. 1, schlieren diagrams for extracts from cells incubated for 30 and 150 min. with 'Chloromycetin' are contrasted with one of those obtained in the absence of the drug. Previously[2], prominent components have been designated 40, 29 and 20S. for ease of reference, although these values are subject to variations, particularly in the crude extracts studied; in the present series the measured values are respectively about 35, 22 and 18S. The additional material responsible for enlargement of the peaks at 18 and 14S. is probably the 'unstable ribonucleic acid' sedimenting as nucleoprotein, which other workers have shown to be synthesized by bacteria in the presence of 'Chloromycetin'[6–8]. A small peak sedimenting a little faster than 22S. is also seen in diagram (*b*); this was not present in diagrams for the control or in those taken later in the lag phase for cells treated with 'Chloromycetin'.

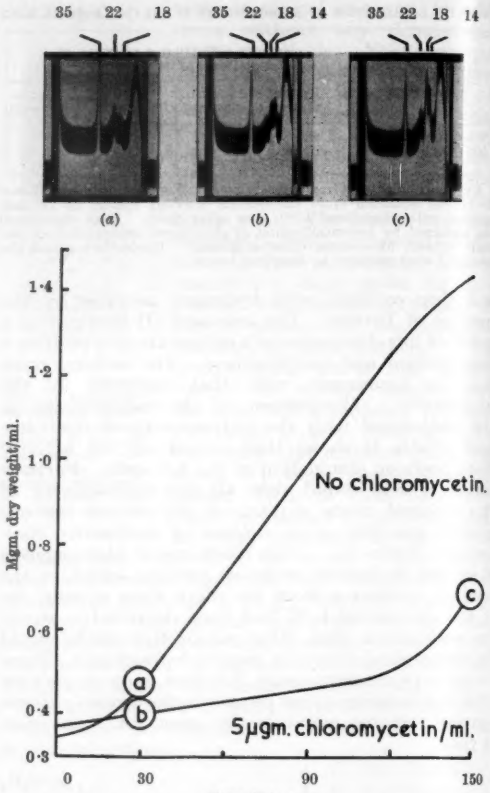

Fig. 1. Schlieren diagrams of extracts from cells (*a*) untreated, and (*b*) and (*c*) treated, with 'Chloromycetin'. Cell-free extracts were prepared in 0·06 *M* phosphate buffer at times indicated on the growth curves and were each diluted to 10 mgm. protein/ml. Photographed of the same schlieren angle (41°) at 16 min. after reaching speed of 187,000*g*. The numbers above the photographs give the uncorrected sedimentation coefficients of boundaries in Svedberg units

A second effect of 'Chloromycetin' is that produced on the '29S. component', which in Fig. 1 has a measured coefficient of 22S. As the 18 and 14S. peaks enlarged in the early part of the lag period due to the drug, so the 22S. peak diminished; and when cell-division began at 120–150 min., the 22S. peak increased rapidly in area, as can be seen by comparing diagrams (*b*) and (*c*). The area of the 35S. peak changed little during these experiments. An increase in the '29S. component' at the onset of logarithmic growth is normally observed[2]; further, this component remains when '40S.' breaks down due to changes in ion concentrations which do not impair cellular metabolism. If ribonucleoprotein particles of a critical size have a specific role in, say, synthesis of bacterial protein, then the '29S. component' appears from the present work more likely to be involved than larger units. Attempts to assign particular functions in the living cell to components of preparations made from them must always take account of the possibility that particles may have arisen simply by mechanical disintegration of larger structures. Smaller units do not always arise from

such processes, however; thus, the ribonucleoprotein components of bacterial cytoplasm tend to aggregate or associate in the presence of magnesium ions; and unless the concentrations of these and other ions in extracts approximate to those in the living cell, the larger particles may have no greater metabolic significance than the smaller ones.

Pardee, Paigen and Prestidge[8] also found that the '29S. component' disappeared from extracts of cells which had been incubated with 'Chloromycetin' but they found no additions to the schlieren diagrams at 18 and 14S. such as we have described. However, until we have completed work on the factors affecting stability of this additional material, it must not be concluded that our results are opposed to those of Pardee *et al.* Thus we have studied cultures containing the rather high concentration of 6·5 m*M* magnesium sulphate which favours ribonucleoprotein association; and it has been observed that degradation of ribonucleic acid formed during 'Chloromycetin' treatment is rapid when cells are suspended in phosphate buffer[6], conditions which also favour breakdown of the ribonucleoprotein particle sedimenting at 40S.

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Effect of Salicylate on Muscle Phosphorylase

During the course of an investigation of the effects of salicylate on glucose metabolism it was observed that incubation of the isolated rat diaphragm in a Krebs–Ringer bicarbonate medium containing salicylate caused a loss of glycogen from the muscle. Such an observation had been made previously by Smith and Jeffrey[1], who employed a phosphate medium with higher levels of salicylate. Under the conditions of our experiments, however, the loss of glycogen from the diaphragm occurred mainly within the first 30 min. of incubation and thereafter occurred at a much slower rate despite the fact that muscle glycogen was still present in abundant amounts (a paper describing this and other effects of salicylate on glucose metabolism is in preparation). In an attempt to explain the alteration in rate of glycogenolysis occurring after 30 min., assays were carried out of active (*a* form) and total (*a* + *b* form) phosphorylase present in the muscle.

Fed male Sprague–Dawley rats (150–175 gm.) were killed by stunning and decapitation. 3–4 isolated hemidiaphragms were placed in a 25-ml. flask with 5 ml. of Krebs–Ringer bicarbonate medium

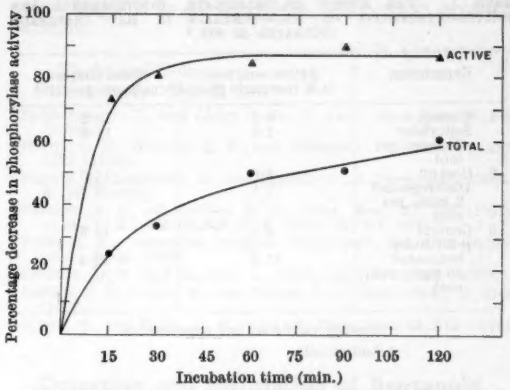

Fig. 1. Effect of incubation with salicylate on muscle phosphorylase in rat diaphragm

*p*H 7·4 containing 100 mgm. glucose and 30 mgm. salicylate/100 ml. (this is a concentration of salicylate which when present in human blood is in the nearly toxic range). As a control, the paired hemidiaphragms were placed in medium without salicylate. After being gassed with 95 per cent oxygen, 5 per cent carbon dioxide for 30 sec., the flasks were stoppered and incubated for varying periods of time in a Dubnoff shaker at 37° C. At the end of the incubation a 10 per cent homogenate of the diaphragms was made in the cold with a Potter–Elvejhem homogenizer, using 0·01 *M* disodium versenate in 0·01 *M* phosphate buffer *p*H 7·4 as the homogenizing fluid. The homogenate was centrifuged to precipitate cell debris, and the supernatant fluid was diluted 1:8 with cysteine-glycerophosphate buffer *p*H 6·0.

The phosphorylase activity of the supernatant fluid was assayed by Cori, Illingworth and Keller's method[2] and expressed as μM inorganic phosphorus[3]/mgm. of protein[4] in 20 min. Concomitant determination of glycogen[5] revealed that glycogen was synthesized in stoichiometric amounts to inorganic phosphorus liberated. When phosphorylase activity was measured by synthesis of glycogen, the findings with salicylate paralleled those obtained by measuring liberation of inorganic phosphorus. Phosphoglucomutase activity was minimal in both control and salicylate-treated preparations.

The results are shown in Fig. 1, each point representing an average of two experiments. At the end of a 15-min. incubation of the diaphragm with salicylate a 70 per cent decrease in active phosphorylase (*a* form) had occurred, eventually reaching about an 87 per cent decrease in activity. Total phosphorylase (*a* + *b* forms) showed a decrease in activity but at a much slower rate. In representative experiments shown on Table 1 the quantity of active phosphorylase in the controls ranged from 34 to 50 per cent of the total amount of enzyme present. This was reduced to 10 per cent by incubation with salicylate for 1 hr.

Since salicylate has been known to uncouple oxidative phosphorylation[6], experiments were performed with dinitrophenol, another uncoupling agent. Table 1 demonstrates that dinitrophenol produces a similar effect on muscle phosphorylase. On the other hand, parahydroxybenzoate, an isomer of salicylate, caused no decrease in the enzyme activity. Studies carried out on crystalline rabbit muscle phosphorylase

Table 1. The Effect of Salicylate, Dinitrophenol and *p*-Hydroxybenzoate on Phosphorylase in Rat Diaphragm incubated 60 min.*

	Experiment	Active enzyme (*μM* inorganic phosphorus/mgm. protein)	Total enzyme (*μM* inorganic phosphorus/mgm. protein)
1	Control	8·1	18·2
	Salicylate† 30 mgm. per cent	1·3	11·6
2	Control	4·8	14·0
	Dinitrophenol 2 mgm. per cent	0·5	5·3
3	Control	9·3	18·5
	p-Hydroxybenzoate† 30 mgm. per cent	11·0	22·4

* Average values for two experiments.

† Sodium salt.

showed that salicylate in the concentration used in the diaphragm experiments produced no decrease in enzymatic activity of the crystalline material (obtained from Sigma Chemical Co., St. Louis, Mo., 2,000 u./mgm. all in active form).

In one group of experiments epinephrine hydrochloric acid (10 γ/ml.) was added to the media after the diaphragm had been incubated with salicylate for 30 min. During subsequent incubation for an additional 60 min., epinephrine increased the active phosphorylase by more than 100 per cent of the low value found in diaphragms incubated with salicylate a total of 90 min. Epinephrine had little or no effect on the level of total phosphorylase.

Since salicylate does not affect the activity of the crystalline enzyme, the decrease in phosphorylase activity in the diaphragm resulting from salicylate treatment is probably a secondary effect on one or more factors necessary for maintenance of the *a* and *b* forms of phosphorylase in the muscle. The initial and most profound effect is a decrease in active phosphorylase which could result either from a stimulation of the *PR* enzyme[7] converting the *a* to the *b* form, or from an inhibition of the activating enzyme[8] which converts *b* to *a* and which is dependent on adenosine triphosphate. The slower decrease in total phosphorylase suggests that the *b* form normally activated by adenosine-5′-phosphate is converted to a form no longer activated by the nucleotide. The effects of salicylate on phosphorylase would adequately explain the observed effects of this compound on the rates of glycogenolysis in the diaphragm.

We wish to express our thanks to Dr. Marshall Nirenberg for his helpful suggestions during the course of this work.

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CHEMISTRY

5-Co-ordination of Divalent Copper

Considerable attention has recently been given to the co-ordination of additional ligands along the axis normal to the molecular plane of planar 4-co-ordinated complexes. Ballhausen and Liehr, for example, explain the blue and yellow isomers of Lifschitz's nickel stilbene-diamine salts in terms of co-ordination of the associated anions in this way[1]; Harris, Nyholm and Stevenson have shown by X-ray analysis the analogous attachment of iodide ions in *bis*-(*o*-phenylene-*bis*-dimethylarsine)palladous iodide[2] and Sacconi, Lombardo and Paoletti have determined stability constants for the adducts of heterocyclic bases with the planar inner-complex nickel diacetyl-*bis*-(benzoylhydrazone) in benzene solution[3].

The resistance of planar complexes of divalent nickel, palladium and platinum to further co-ordination derives from the effect of the ligand field in so raising the energy of the $d_{x^2-y^2}$ orbital, which points directly at the ligands, that it remains unoccupied; the consequent pairing of electrons in the d_{z^2} orbital produces regions of high electron density normal to the molecular plane, so resisting the approach of further ligands[4]. A similar situation arises in planar cupric complexes (the $d_{x^2-y^2}$ orbital being then singly occupied), and the elongated octahedral co-ordination of this ion in crystalline salts has been known for many years[5]; but apart from this, comparatively little attention has been given to co-ordination of further groups normal to the molecular plane of cupric complexes, though the solubilities of cupric α-amino-acid chelates suggest that solution may occur by co-ordination of water in this way[6].

It thus seems of interest to report the formation in non-polar solvents of 5-co-ordinated complexes by attachment of heterocyclic bases to the planar molecules of cupric acetylacetonate and cupric ethyl-acetoacetate.

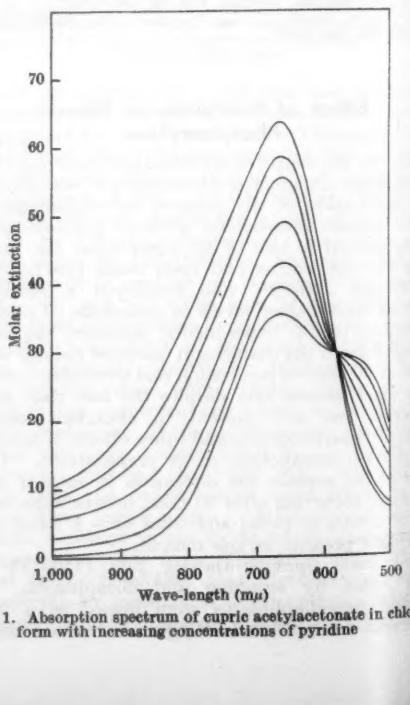

Fig. 1. Absorption spectrum of cupric acetylacetonate in chloroform with increasing concentrations of pyridine

The absorption of cupric acetylacetonate in chloroform solution is considerably modified on addition of pyridine, most noticeably by a progressive increase in extinction of the peak at 660 mμ with increasing concentration of the base. The successive absorption curves have a sharply defined isosbestic point (Fig. 1), indicating a two-phase equilibrium. The equilibrium constant, calculated from the molecular extinctions, is of the form :

$$k = \frac{[\mathrm{Cu(acac)_2.pyridine}]}{[\mathrm{Cu(acac)_2}] \times [\mathrm{pyridine}]}$$

showing that only one molecule of pyridine is co-ordinated. Though formation of the 5-co-ordinated complex is incomplete, even with a two hundred-fold excess of pyridine, the equilibrium constants are so consistent over the whole range that any alternative form of the equilibrium constant, such as that required for 6-co-ordination, can be excluded. Thus, at 20° C. with 5×10^{-3} *M* cupric acetylacetonate the results in Table 1 were obtained. Similar results were obtained with piperidine ($k = 3 \cdot 3$; extrapolated extinction of complex = 86·5). It is significant that the extrapolated absorption curves of the pyridine and piperidine complexes are, within the limits of error, identical with those observed by Belford, Calvin and Belford[7] using pure pyridine or piperidine as solvents, so that any possibility of the completion of 6-co-ordination by the solvent may be discounted. This possibility would not arise in paraffin solvents, but the solubility of cupric acetylacetonate in these is too low to allow their use ; cupric ethylacetoacetate, however, is much more soluble in paraffins, and parallel results have been obtained for its reaction in *cyclo*hexane solution at a concentration of 10^{-3} *M* with piperidine ($k = 640$; extrapolated extinction = 83), pyridine ($k = 54$; extrapolated extinction = 76), γ-picoline ($k = 36$; extrapolated extinction = 77) and α-picoline ($k = 4 \cdot 9$; extrapolated extinction = 76).

Table 1

Pyridine (*M*/l.)	0	0·045	0·105	0·195	0·400	0·600	1·00	∞
ε (660 mμ)	35·6	39·4	43·0	47·8	55·5	58·5	63·8	75·6*
Cu 5-co-ordinated (per cent)	0	9·5	18·5	30·5	49·5	57·0	70·5	100
k (mean = 2·3)	—	2·33	2·15	2·25	2·45	2·22	2·39	—

* Extrapolated.

The general trend of the equilibrium constants for combination with cupric ethylacetoacetate is similar to that observed by Sacconi, Lombardo and Paoletti[3] for co-ordination to nickel, including the low value for α-picoline, no doubt due to steric interference by the methyl group. The much lower stability of the acetylacetonate adducts suggests that the copper atom in these carries a much smaller net charge, as would be expected from general considerations of structure and from the polarographic results of Calvin and Bailes[8], though a small part of the effect may be due to the change of solvent.

The use of *cyclo*hexane as solvent eliminates any possibility of co-ordination by the solvent and these stability constants thus share with those of Sacconi, Lombardo and Paoletti the unusual property of referring to a process of co-ordination uncomplicated by the displacement of co-ordinated solvent molecules, implicit in all equilibria observed in aqueous solution.

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Detection and Estimation of Benzenoid Compounds by Chromatography

Methods have frequently been described for the detection and estimation of heterocyclic compounds on chromatograms by ultra-violet photography[1–4]. These methods use a mercury discharge lamp suitably filtered. This type of lamp, however, yields predominantly the 253·7 mμ mercury line and is only suitable for compounds having a considerable absorption at this wave-length. With the benzenoid ring class of compounds, the absorption maxima are generally between 265 mμ and 285 mμ, frequently with the trough near the 253·7 mμ line. Consequently, in order to detect these compounds by a similar technique, a different source of light is necessary.

Table 1

Compound	Absorption	
	Maximum (mμ)	Minimum (mμ)
cis-trans β-Chloromuconic acid	264	—
cis-cis Muconic acid	259	—
2-Hydroxy-4-chlorophenoxyacetic acid	283	255
4-Chloroguiacol	283	255
p-Chlorophenoxyacetic acid	280	247
4-Chlorocatechol	284	250

A hydrogen discharge lamp, similar to that used in the 'Unicam' quartz spectrophotometer (*S.P.* 500), was used as the source of ultra-violet light, utilizing the stabilized power unit of the *S.P.* 500. It was necessary to reduce the continuous spectrum of the hydrogen lamp to a band of 260–300 mμ with a peak at 285 mμ. An aqueous nickel sulphate solution (27·5 gm./200 ml.) has a high transmission of light between 220 mμ and 360 mμ and also above 400 mμ. An aqueous solution of quinine sulphate (125 mgm./250 ml. + 1 drop of sulphuric acid) transmits a band between 260 mμ and 290 mμ and also above 360 mμ. A mixture of three parts nickel sulphate solution to one part of quinine sulphate combined with a 'Chance' *OX* 7 filter, to cut off the visible light, provided a suitable stable filter system. The transmission curves of the component filters are shown in Fig. 1. The filter compartment comprised of the *OX* 7 filter as one face and a quartz plate as the other (3 in. × 3 in., optical faces) with a rubber cushioned 'Perspex' 'U' (4 in. × 4 in. × ½ in., diameter of central hole being 2 in.) separating the two. Two brass plates (4 in. × 4 in. × ¼ in.) with 2-in. diameter holes cut centrally, also rubber-cushioned, were placed at each end of the compartment and the whole bolted together at the corners with brass bolts to a suitable lamp

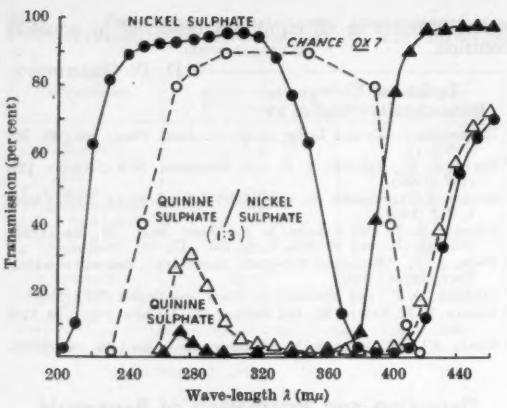

Fig. 1. Transmission spectra of filters

housing. A heat–light baffle was made at the top of the lamp housing. The chromatogram from which the solvent system had been completely removed was stretched tightly over Ilford bromide document paper No. 60 and exposed to the light source. The exposure was approximately 30 sec. at 2 ft. Table 1 shows the absorption maxima and minima of some metabolic intermediates which were resolved in this manner[5–7]. It was possible to trace the spots on to the chromatogram, and after elution estimate them quantitatively in the ultra-violet spectrophotometer. 0·10 μmole of *cis-trans* β-chloromuconic acid, 1 μmole of 2-hydroxy-4-chlorophenoxyacetic acid and 1 μmole 4-chlorocatechol could be estimated in this way.

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Melting Point and Sublimation of Molybdenum Disulphide

Molybdenum disulphide has until recently been reported as having a melting point[1] of 1,185° C. In 1956, however, Zelikman and Belyaevskaya[2] reported that samples of molybdenum sulphide did not melt at temperatures up to 1,350°, and only those which had been heated to temperatures in excess of 1,650° C. showed any (microscopic) signs of melting. The purpose of the present communication is to report experiments made in connexion with the preparation of clean molybdenum disulphide surfaces, which are relevant to the question of the melting point of the material.

By heating pure powdered molybdenum disulphide, suspended from a quartz spiral, *in vacuo*, plots of weight vs. temperature were obtained. The sample was purchased from the Alpha Molykote Corp. of Stamford, Conn., and contained 58·9 per cent molybdenum (calc. for molybdenum disulphide, 60·0 per cent). The sensitivity of the system was about 0·5 per cent of the sample weight and the ultimate vacuum in the system better than 10^{-6} mm. mercury. The heated zone of the apparatus was made from fused quartz. Apart from losses in weight at lower temperatures due to the evolution of material adsorbed from the atmosphere, the weight losses of interest are one of about 2 per cent in the temperature 850–950° C., which presumably corresponds with the volatilization of surface molybdic oxide, and a much larger one at temperatures in excess of 1,050° C., when a brown film begins to cover the inside of the apparatus. This film, when examined by the electron-diffraction technique, proved to be hexagonal molybdenum disulphide. The weight loss at this highest temperature was proportional to the time the specimen was held at that temperature. The residual solid was observed to be a loose sinter of no great mechanical strength, even after the sample had been held at 1,250° C. for 4 hr. At this temperature, the quartz wall was attacked by the deposited molybdenum disulphide, with the formation of a zone of powdered silica. The net result was the ultimate devitrification of the apparatus.

Table 1

Sample No.	Temperature, °C (± 20°) at which sample was taken	Gas pressure (μ)	Composition in sample bulb
1	1,000	2	CO or N_2 + a little H_2
2	1,200	11	CO or N_2
3	1,450	0·03	CO or N_2
(Sample was allowed to cool and experiment recommenced after the system had been pumped down (once more, hard))			
4	980	2	95 per cent CO 5 per cent H_2
5	1,400	0·8	85 per cent CO 15 per cent H_2
6	1,510	1	88 per cent CO 12 per cent H_2
7	1,720	0·5	85 per cent CO 15 per cent H_2
8	1,800	0·3	75 per cent CO 25 per cent H_2

A pair of specimens of pure natural massive molybdenite (locality Kingsgate, New South Wales, molybdenum obs. 58·4 per cent, no other metals present to the extent of more than a trace except lead, 0·01 per cent) were mounted by molybdenum bolts to molybdenum leads in such a way that the resistance, and hence the continuity, of the specimens could be checked. A molybdenum crucible was arranged around the specimens, the assembly placed in a quartz envelope, and attached to a high-vacuum pumping system via a gas sample manifold. The specimens were heated inductively, and the evolved gases were sampled and afterwards analysed on a mass spectrometer (Table 1). Surprisingly, the gases contained no sulphur-bearing materials at all. Temperatures were measured using a calibrated disappearing-filament pyrometer, with suitable corrections for the emissivity of molybdenum metal as viewed through quartz. Quartz strip shields were used to prevent the formation of a continuous condensed film of the sample around the wall, which would have caused coupling of the radio-frequency field with the conducting deposit, and which also would have prevented accurate observation of the temperature of the crucible.

The specimens did not melt even when held at a temperature of 1,800±20° C. for 10 min. Consequently, the melting range of 1,650–1,700° reported by Zelikman and Belyaevskaya[2] cannot be real: their result may be due to reaction of the sample with its surroundings since they used graphite vessels. Such an artefact is certainly the cause of the very low early value of 450° C. due to Joly[3] for the onset of

sublimation of molybdenite, which in this work occurred around 1,050° C. If molybdenum disulphide obeys the Tammann rule, that is, if it begins to sinter noticeably at a temperature about one-half of its absolute melting point[4], then it would be expected to have a melting point around 2,375° C.

I wish to thank J. Kelly for preparing the vacuum systems and F. J. Norton for the mass spectrometric gas analyses.

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Alicyclicity and Smoke Emission of Coal

MUCH work has been done in the past on the smokiness or the smoke nuisance of coal during combustion, but mainly on its abatement. The fundamental causes of smoke emission have been little studied, though its obvious link with volatile matter and/or tar[1] has been known. Recent dehydrogenation studies[2,3] made by us leading to the determination of alicyclic carbon in coal have resulted in certain findings on the pyrolysis and combustion behaviour of dehydrogenated coals which obviously suggest that alicyclic bodies in coal are the main smoke-forming constituents.

It has been shown elsewhere[3] that dehydrogenated coals (for example, by Vesterberg's technique—dehydrogenation carried out with sulphur below the decomposition point of coal) do not yield any tar and that the char yield increases proportionately to the alicyclic carbon content of coal at the expense of tar-forming bodies. It has been shown[4] that alicyclic bodies in coal are primarily responsible for the formation of tar.

These findings naturally prompted us to study the combustion behaviour of the dehydrogenated coals. As the devolatilization of alicyclic bodies, that is, the tar-forming bodies, is completely inhibited on dehydrogenation, it was anticipated that pyrolysis of such bodies would also be avoided during combustion, resulting possibly in the smokeless burning of such coals. This was found to be so in the case of all dehydrogenated coals prepared from different ranks.

Table 1. ALICYCLICITY AND SMOKINESS OF COAL

Coal	On unit coal (per cent)			
	Carbon	Hydrogen	Alicyclic carbon*	'Smokiness'†
Assam	80·3	5·9	16·1	2·44
Jambad Bhowlah	80·6	5·4	13·7	2·25
Ponlati	83·5	5·5	15·5	2·25
Laikdih‡	87·3	5·3	10·1	1·50
Pootki‡	88·0	5·3	11·2	1·40
Jharia, IX	90·7	4·7	5·5	0·87
Jharia, IX	90·4	4·6	3·6	0·75
Anthracite (South Wales)	93·2	3·5	nil	nil

* Data taken from earlier papers (refs. 2, 3 and 4).
† By 'smokiness' is meant here the soot and free carbon in the flue gas which was trapped and filtered off quantitatively in glass-wool and weighed. The experiments were carried out in a small muffle furnace under identical conditions of air-supply, that is, the ratio of air to the amount of volatiles was kept the same in all cases by adjusting the weight of coal.
‡ Vitrains.

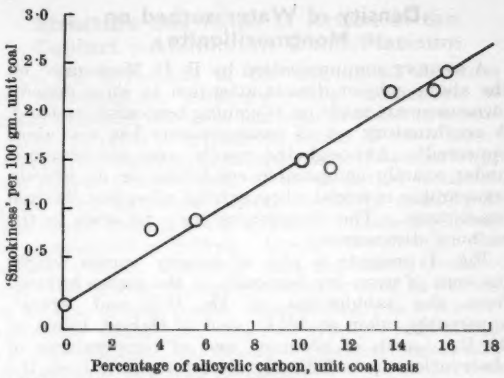

Fig. 1. Relation between alicyclicity and smoke emission of coal

Halogenation also has been found[5] to bring about the same type of dehydrogenation and stabilization of alicyclic carbon during subsequent pyrolysis. Such dehydrogenated coals are also smokeless during combustion. Prior treatment of coal with acids like sulphuric and phosphoric and certain other dehydrating agents like phosphorus pentoxide and potassium hydrogen sulphate also renders a coal smokeless without having to carbonize it. It has been found that during such treatment no tangible loss of carbon or hydrogen takes place, but apparently a reorganization (possibly condensation) of the alicyclic part in relation to the basic aromatic nucleus occurs whereby devolatilization of alicyclic bodies is completely inhibited[6].

Controlled oxidation[7] of any coal will also bring about a similar change.

It would appear, therefore, that smoke emission is primarily due to the alicyclic structures in coal and any process which can help stabilize such structure would make a coal smokeless.

Relative smokiness of different ranks of coal has been measured (Table 1) and is found to bear a linear relationship with alicyclic carbon content of the coals (Fig. 1). Anthracites and semi-anthracites contain very little or no alicyclic carbon, and hence they are smokeless. Semi-coke or char are smokeless fuel as these carbonized products do not contain any alicyclic structure. Thus it is possible to make a smokeless fuel from any coal without having to carbonize it. The inhibition of tar formation on oxidation of coals has been known for a long time; but the fundamental causes have become evident from our studies on dehydrogenation of coals.

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Density of Water sorbed on Montmorillonite

A RECENT communication by R. C. Mackenzie[1] on the above subject directs attention to some density measurements made on Wyoming bentonite pastes[2,3]. A confirmatory set of measurements has also since appeared[4]. Although the results were not obtained under exactly comparable conditions or on exactly comparable material, they exhibit adequate internal consistency. The divergences seem to arise in the authors' discussions.

Fig. 1 presents a plot of density versus weight per cent of oven-dry bentonite in the pastes reduced from the tabulations of De Wit and Arens[2], apparently taken at 20° C., and of Oakes[4], taken at 30° C. Levels of accuracy and of temperatures of observation are sufficiently close for points from the two sources to lie on a smooth curve. It also essentially includes the observations of Anderson and Low[3] throughout the range of their results.

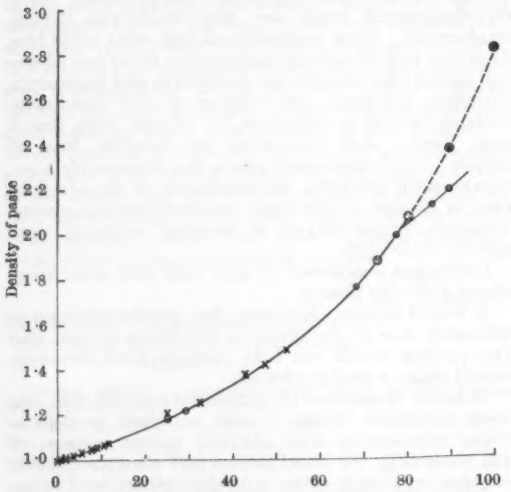

Fig. 1. Densities of Wyoming bentonite pastes. ×, Oakes's results; ○, De Wit and Arens's results; ⊗, approximate positions of X-ray densities for the water contents at which the bentonites exhibit three, two and one layers of hydration water, and for the bare lamellæ. The dashed extrapolation indicates the trend which a curve would follow if no porosity were consequent to the shape of independent flakes

Montmorillonite, the main mineral constituent of bentonite, is abundantly documented as having a remarkable laminar structure in which individual laminæ are more or less independent. In the absence of an enveloping medium, the density of an aggregate of independent flakes makes up a fraction of the true density roughly comparable to the 91 per cent of a given volume which can be occupied by a packed set of equal disks. That is, the aggregate volume per disk is 110 per cent of the volume of a single disk. In an excess of enveloping medium, each lamina occupies only its own characteristic volume.

The unit dimensions, based on Pézerat and Méring's[5] X-ray measurement of parameters within layers, and the structural formula of montmorillonite in analysed Wyoming bentonite, afford a calculated density of 2·83 for the laminæ alone. This is in suitable agreement with the observed density of pyrophyllite, in which layers of nearly identical dimensions and compositions are not independent, and is about 1·1 times the 'density' measurements obtained from dry montmorillonite.

Table 1

Conc. wt. per cent oven-dry bentonite in paste	Density determination		Average specific volume of water	Apparent specific volume of bound water, if bound water equals 0·3 the weight of bentonite
	Oakes	De Wit and Arens		
0·000	0·99564	(0·998)	1·0044	
0·982	1·00155		1·0048	
1·795	1·00730		1·0044	
3·64	1·01950		1·0045	
5·35	1·03145		1·0044	
7·52	1·04594		1·0051	
8·70	1·05452		1·0050	
10·60	1·0687		1·0048	
11·42	1·0750		1·0047	
24·93		1·186	1·008	1·06
25·00	1·200		0·994*	
29·05		1·222	1·009	1·06
32·30	1·2572		1·0058	1·03
42·75	1·3719		1·0158	1·06
47·6	1·4241		1·019	1·06
52·4	1·4894		1·021	1·05
68·5		1·772	1·023	1·04
77·9		2·001	1·02	
85·75		2·134	1·16	
89·60		2·199	1·33	

* Note departure from curve in Fig. 1

In Table 1, apparent average specific volumes of water in the several pastes cited are arrived at by simple subtraction of the volumes of the montmorillonite laminæ present from the total volume.

It is also frequently inferred that montmorillonite laminæ rather strongly control up to about one-third of their own weight in water molecules (cf. Bradley[6]). If normal specific volume be assumed for the residue of water in these pastes which is not so controlled, the apparent specific volume of controlled water may be calculated and is listed for several cases in Table 1.

In Oakes's pastes the exchange base present was sodium ion, and it must be presumed that these ions were associated mainly with the bound fraction. Their abundance with respect to bound water is about 8 per cent by weight, or 2 per cent by volume. Allowance of 2 per cent positive error for each of the sodium ion paste entries still leaves an average of about 1·04 for the specific volume of the bound water.

The more elegant procedure of Anderson and Low[3] avoids the rather complicated assumptions outlined above by measuring the rate of change of volume of a paste as water is expressed from it. At the level of 62·5 per cent solids (Fig. 1), they found apparent specific volumes for the water being expressed of 1·02–1·03, in excellent agreement with the calculated volumes at comparable solid content in Table 1.

In the region 75 per cent solids (77 per cent if the estimate for bound water of 0·3 by weight of the solid were assumed to be a fixed quantity) the water becomes insufficient to constitute a continuous phase. Apparent specific volumes for water then lose their meaning, and the density determinations depart gradually from the smooth 'theoretical' curve toward the bulk density of packed solid disks. Instead of the 'apparent molar volumes' for the last two entries in Table 1, apparent porosities may be estimated, and they are about 3 per cent and about 6 per cent

respectively. Apparent porosities for cited weighed oven-dried aggregates are about 10–15 per cent.

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Dr. Bradley has very successfully correlated data from diverse fields of study to show the essential agreement in density determinations on montmorillonite pastes. In this connexion it is interesting to note that early determinations carried out at this Institute, and referred to previously[1], fall quite nicely on the spur of the curve above 77 per cent solids.

In considering the extrapolated part of the curve, however, it must be remembered that montmorillonite oven-dried even at 135° C. (as used by Oakes[2]) always contains some residual sorbed moisture (the amount may be a few per cent[3]), and hence it is rather surprising that Dr. Bradley's density value for dry montmorillonite (calculated from X-ray and chemical data) fits the curve so closely. One would have expected some slight discrepancy in view of the fact that the pastes involved were made up with oven-dry montmorillonite. A montmorillonite (Wyoming bentonite) for which we have X-ray and accurate chemical data[3] gives a calculated density of 2·78—somewhat lower than Dr. Bradley's value, and the true hypothetical value for 100 per cent oven-dry montmorillonite would be expected to be even lower. The value for dry montmorillonite is somewhat critical in estimating the specific volume of the 'bound' water and, furthermore, it might be remarked that the bulk specific volume of the 'bound' water would be expected to vary with the exchangeable ion and may not be the specific volume of all fractions of this water. One wonders, too, whether it would necessarily be expected that the extrapolated density : montmorillonite-concentration curve need be a smooth continuation of that obtained in the lower concentration regions.

In view of the difficulties in assessment of the final part of the curve (more than 77 per cent solids) there is, to my mind, as yet no unequivocal evidence from density measurements as to the configuration of the *first* amounts of water sorbed by montmorillonite.

The divergences in discussion mentioned by Dr. Bradley surely arise from the fact that different authors have been considering the interpretation of results from rather different points of view. In the lower solids-concentration region all are agreed that density measurements can give an overall estimate of the density of the water present, the essential accuracy of which is clearly demonstrated by the elegant experiments of Anderson and Low[4].

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Structure and Mode of Action of the Contact γ-Aluminium Oxide/Platinum

On the hypothesis of the free-radical structure of heterogeneous catalysts[1,2], the mechanism of many catalytic reactions has been deduced in recent years[3]. In order to explain the action of the γ-aluminium oxide (Al_2O_3)/platinum contact, the structure of the radical γ-Al_2O_3 (ref. 4) as an active transient phase with structural defects should be considered. The model formula of the non-active oxide Al_2O_3 can be represented as follows: O=Al—O—Al=O. The active γ-Al_2O_3 contains the radicals: O=Al— and —O—Al=O. Though this formula could be written in several similar forms, because Al_2O_3 is a macromolecular compound, only two types of radical can be expected, namely, R=Al— (electron donor) and R=Al—O— (electron acceptor).

Since the contact γ-aluminium oxide/platinum is obtained as a product of the action of chloroplatinic acid on active γ-aluminium oxide, there is a possibility of exchange between the two compounds, according to the equation:

$$(O{=}Al{-}\ {-}O{-}Al{=}O)_2 + 2H^+PtCl_6^{2-} \rightleftharpoons (O{=}Al{-}OH)_2 + 2(AlO)^+PtCl_6^{2-}$$

Under the influence of an excess of chloroplatinic acid, the dissociation of aluminium–platinum compound goes backwards; this can also be explained by the action of the active γ-aluminium oxide as a chromatographic column[5]. In the stream of hydrogen the undissociated $(AlO)_2PtCl_6$ undergoes reduction as follows:

$$(AlO)_2PtCl_6 + 3H_2 \rightarrow (O{=}Al{-})_2 + Pt + 6HCl$$

and as a result of this the radical O=Al— appears, which is necessary as an important link in the chain of reactions leading to the hydrogenation of benzene. Thus the active γ-aluminium oxide acquires electron donor properties. But when the concentration of chloroplatinic acid is small, the complete suppression of the dissociation of $2(AlO)^+PtCl_6^{2-}$ is doubtful, this compound being able, under the influence of hydrogen, to retain its ionic form. This checks the regeneration of the primary radical O=Al—, according to the reaction:

$$2(AlO)^+PtCl_6^{2-} + 2H_2 \rightarrow 2(AlO)^+2Cl^- + 4HCl + Pt$$

This explains why γ-aluminium oxide/platinum contacts with small contents of platinum lose their activity quickly[6], because, in my opinion, in the absence of sufficient numbers of O=Al— radicals, platinum only activates hydrogen so long as it is saturated with it or with a hydrogen compound (*cyclo*hexane):

$$Pt + H_2 \rightarrow Pt/H + H$$

But when the radical O=Al— appears and co-operates with metallic platinum, then platinum, passing into the atomic state, can also make use of the electrons of O=Al— and of molecular hydrogen in turn, so that hydrogen is activated. In consequence of this the hydrogen electron, together with its proton, is as it were thrown aside after the electron arising from the O=Al— radical becomes available, and so on in a constantly repeating rhythm[7]. The mechanism of the reaction of hydrogenation of benzene at the γ-aluminium oxide/platinum contact can be represented in the form of a chain reaction, which is accompanied by a migration of electrons[7].

$$O{=}Al{-} + Pt + H_2 \rightarrow O{=}Al{-}\ldots Pt\ldots H + H$$
$$3\,(O{=}Al{-}\ldots Pt\ldots H) + 3H + C_6H_6 \rightarrow C_6H_{12} + 3\,(O{=}Al{-}\ldots Pt),\ \text{etc.}$$

The γ-aluminium oxide/platinum contacts are prepared by mixing a suspension of the oxide with the solution of chloroplatinic acid; in consequence the acid is adsorbed on the surface of aluminium oxide. The method described by Trzebiatowski and Kubicka[6] produces less active catalyst than that of Kobozev and co-workers[8]. It should be made clear that in the first case the authors worked at a higher temperature-range of the mixture (on a water-bath), while in the second case all operations are carried out at room temperature. It is believed that the O=Al— radicals disappear more easily at higher temperatures, transforming themselves into cations $(AlO)^+$ according to the first reaction given above.

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GEOLOGY and MINERALOGY

A Marine Transgression of Boreal Age in the Southernmost Part of Norway

In the summer of 1956 the Quaternary history of a number of trough-shaped basins was investigated in the area between Lindesnes and Kristiansand. In one such basin, at Dostad in the innermost part of Hartmarkfjord (lat. 58° 02′ N., long. 7° 38′ E.), a mire was found at a depth of about 1·5 m., lying between layers of marine sediments (Fig. 1). The basin is very well sheltered from the sea by, among other things, a rock threshold which is about 2 m. above present sea-level. The mire is 1·5–1·7 m. thick.

A variation in the proportions of marine to freshwater diatoms was observed in the mire. The 50 cm. directly above the marine clay (*e*) and including the gyttja (*d*) contains only freshwater forms. Farther up, a few salt water forms appear together with freshwater species. The proportions of salt water forms increase upwards until at the top only marine forms are present.

The mire rests on marine clay and is covered by marine diatomaceous earth (quantities of *Melosira* (*Paralia*) *sulcata* and many *Navicula lyrata* types) on top. It seems probable that these diatoms have actually lived here.

Samples were collected for pollen and diatom analyses by means of a Hiller peat sampler. Miss Kari Egede Larssen, of the Norwegian Geological Survey, has been kind enough to carry out pollen analyses of samples from the base and the top layers

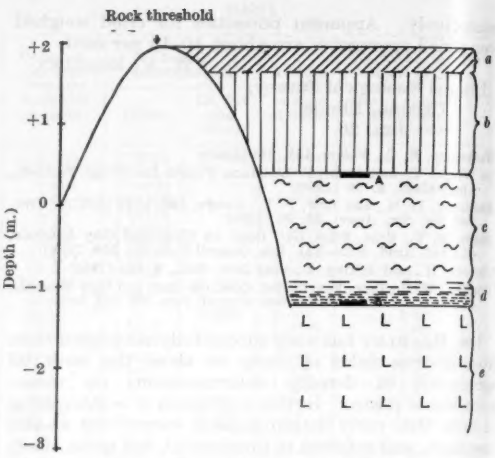

Fig. 1. Vertical scale exaggerated. *a*, Cultivated soil; *b*, marine diatomaceous earth; *c*, 'peat'; *d*, freshwater gyttja; *e*, marine clay

of the mire. Both samples contain considerable quantities of *Corylus* (15–17·5 per cent), but practically no *Alnus* pollen. In addition, many macroscopic fossils were found, among which were nuts and leaves of *Corylus* and tree branches. Miss Egede Larssen states that in all probability the samples are of boreal age.

For carbon-14 datings, horizontal slices of the 'peat' 2–3 cm. thick were collected. One was taken from the top of the mire and one from the bottom (Fig. 1, *A* and *B*). The datings have been carried out by the Radiological Dating Laboratory at the Norwegian Institute of Technology in Trondhjem. The ages of the samples were found to be 8,770± 100 years (B.P.) and 9,410±220 years (B.P.) respectively.

This part of Fennoscandia is peripherically situated with respect to the rise of the land after the last Ice Age and the marine transgressions could occur because eustatic movements would easily be stronger than the isostatic movement.

Referring to the above-mentioned datings, one must accept that the Dostad basin was isolated from the sea because of a regression which occurred approximately 9,400 years ago. A rich vegetation came into existence and lasted until approximately 8,800 years ago, when a transgression of the sea, probably eustatic in origin, drowned this boreal vegetation.

Such a great amount of marine diatomaceous earth as was formed afterwards has, apparently, never previously been recorded in Norway. Marine diatomaceous earth has been observed in Sweden[1].

Several Swedish authors[2,3] have given diagrammatic representations of the movement of the shoreline in the Gothenburg area, and these show that a transgression began to make itself clearly apparent about 7000 B.C. One of these authors repeats this again in a later publication[4]. The "time of sinking of the land" must in any event have begun before *Alnus*, *Quercus* and *Tilia*, etc., appeared in the region[1] (northern Halland). Fromm is quoted[5] as having found, from the pollen analysis results of varved sediments, that the *Alnus* curve began about 6300 B.C. This dating is valid for southern Sweden. A great peat column at Adak in Northern Sweden has

been dated by the carbon-14 method, thus placing the beginning of the *Alnus* curve at 6620±125 B.C.[5]. The pollen analysis from the upper part of the mire (Fig. 1,c) indicates that its age is apparently not far from the time when the *Alnus* curve began. This correlates very well with the radiological dating from Sweden.

Marine sediments resting directly upon a boreal terrestrial deposit have apparently not been previously reported in Norway. The occurrence of marine diatoms, as described above, indicates that sea-level was not far below the rock threshold and that waves were able to break over it, for example, during storms and exceptionally high-water levels. The minimum level of the boreal shore-line, judging by the evidence of the diatoms, was not far from the present sea-level in the area. However, work on a graph of the movement of the shore-line is being carried out at present, and more detailed results will be published later.

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Olivine-Spinel Transformation

IN the light of A. E. Ringwood's recent synthesis of a spinel form of fayalite (private communication), Fe_2SiO_4 (the iron end-member of the fayalite–forsterite mixtures which comprise the bulk of natural olivines), it seemed worth while to attempt a synthesis of a spinel form of forsterite, Mg_2SiO_4. Ringwood prepared the fayalite-spinel at about 50 kilobars and 500° C., and his calculations indicated that the forsterite-spinel should become stable at about 100 kilobars and 500° C. It is possible that olivine is abundant in deeper layers of the Earth (50–1,000 km.) and hence some knowledge of its phase transitions would be of geological interest[1].

To study these possible phase transitions, appropriate mixtures of dry and hydrous oxides were loaded into a carbon capsule contained in a high-pressure, high-temperature apparatus. After the pressure on the capsule was increased to the desired level, it was electrically heated to about 550° C. for about 20 min. (Crystals of 10 or 20μ average diameter formed in 5 min.) Then the sample was quenched to room temperature and the pressure was reduced to atmospheric. In this way any phases formed at high pressure would tend to be preserved. Various hydrated phases formed if the maximum temperature did not exceed about 500° C.

Table 1

Charge	Pressure (kilobars)	Products identified
$2\,Mg(OH)_2 + SiO_2 \cdot nH_2O$	95–130	Forsterite
$Fe + Fe_3O_4 + SiO_2 \cdot nH_2O$	110	Ringwood's fayalite-spinel (Debye–Scherrer patterns agree)
$Fe + Fe_3O_4 + MgO + SiO_2 \cdot nH_2O$	110	Forsterite, fayalite-spinel
Hawaiian olivine	93–(hot)	Olivine melted and frozen this run. Olivine recovered
Moist Hawaiian olivine	90–110	Olivine unchanged
$2\,Mg(OH)_2 + 0{\cdot}9\,SiO_2 + 0{\cdot}1\,GeO_2 + H_2O$	110	Forsterite
$2\,Mg(OH)_2 + SiO_2 \cdot nH_2O$ + 5 per cent Ni_2GeO_4	110	Forsterite
$2\,NiO \cdot SiO_2 \cdot nH_2O$	90–110	Nickel forsterite (no spinel)
$2\,ZnO \cdot SiO_2 \cdot nH_2O$	90	New phase, r.i. 1·78, biaxial. No spinel

Table 1 summarizes the results of these experiments.

Thus no other olivinic spinel other than Ringwood's fayalite-spinel formed in these experiments. Perhaps higher pressures are necessary. This work will be continued.

I am indebted to A. E. Ringwood and Prof. F. Birch for stimulating the work on this problem and for providing some of the oxide mixtures.

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PALÆOMAGNETISM

Late Tertiary Geomagnetic Field in North-western Canada

THE fundamental assumption made in interpreting palæomagnetic results is that the average geomagnetic field corresponds to that of a central axial dipole. This communication reports on some palæomagnetic results which support this assumption and which were made on Late Tertiary volcanic rocks, which were collected during the summer of 1955 from north-western Canada by field geologists of the Geological Survey of Canada from flat-lying, undisturbed, vesicular basalts.

Forty-eight samples were collected from four different localities. The largest suite, twenty-nine amples, was collected by J. O. Wheeler from lavas exposed near Whitehorse, Yukon, at a latitude of 60·5° N. and longitude of 135·0° W. Another nine samples were collected by W. H. Poole near Wolf Lake, Yukon, at 60·0° N. and 130·5° W. L. H. Green collected six samples near Selkirk, Yukon, at 63·0° N. and 138·0° W., and J. D. Aitken collected four samples near Surprise Lake, British Columbia, at 59·5° N. and 134·0° W.

These samples were measured on a magnetometer of the rock generator type at the Geological Survey of Canada during 1958. The results of these measurements are shown in Fig. 1 on a stereographic projection, full and open circles representing north poles on the lower and upper hemispheres respectively. All the rocks collected by Wheeler and Green are reversely magnetized while the rest are normal except for two of Poole's samples, which are almost horizontally polarized.

The mean direction of these rock samples has been computed by reversing all the reversely polarized rocks and adding them to the normal ones. The two horizontally polarized samples are considered to be anomalous, due perhaps to magnetization caused by lightning, and have not been included in the statistical analysis. The mean direction, *H*, with its Fisher statistics, has been listed in Table 1, where it is compared with the field, *F*, produced by a central axial dipole and the present geomagnetic field, *F'*, at

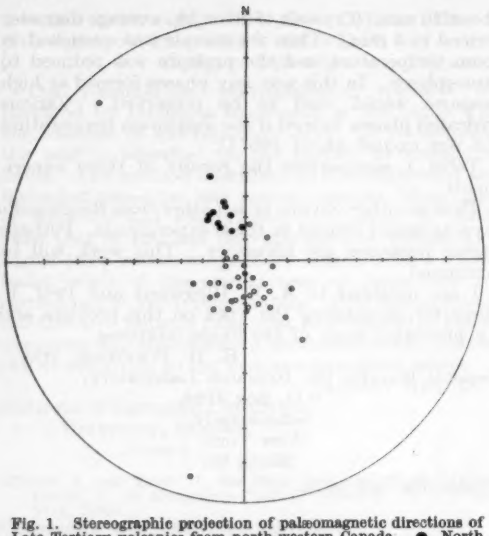

Fig. 1. Stereographic projection of palæomagnetic directions of Late Tertiary volcanics from north-western Canada. ●, North pole on lower hemisphere; ○, north pole on upper hemisphere

60·0° N. and 135·0° W. The λ's are the angles between the palæomagnetic direction, H, and F and F'.

Table 1 shows that the mean palæomagnetic direction of these Late Tertiary rocks is equivalent to the axial dipole field expected at this locality and is significantly different from the Earth's present field. These results are therefore further evidence to support the basic assumption of most geophysical interpretations of palæomagnetism, namely, the average magnetic field of the Earth is due to a geocentric axial dipole.

Table 1

	H	F	F'
D	348·5	0·0°	31·0°
I	+ 75·0	+ 74·0°	+ 76·0°
θ	4·0°	—	—
K	28·0	—	—
N	46	—	—
λ	0°	3·5°	10·5°

D, Declination east of north; I, inclination (+ north pole down); θ, angular radius of circle of confidence at 95 per cent level; K, Fisher's dispersion; N, number of samples.

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P. M. Du Bois

Geological Survey of Canada,
Ottawa. Feb. 23.

PHYSICAL SCIENCES

Simultaneous Occurrence of Sub-Visual Auroræ and Radio Noise Bursts on 4·6 kc./s.

Since July 1958 the red oxygen (6300 A.) airglow has been recorded at Camden, near Sydney (geomagnetic latitude 42° S.), with a sky-scanning photometer. This instrument has been described by St. Amand[1]. These observations frequently detected greatly enhanced emission towards the south, and less often structures such as arcs and rays. We interpret these as auroræ, usually sub-visual, though on seven nights auroræ were seen.

Table 1. Occurrence and Absence of Noise on 4·6 kc./s. and Auroræ

		Noise on 4·6 kc./s.	
		Yes	No
Auroræ	Yes	18	2
	No	6	27

During the same period, radio noise on 4·6 kc./s. was continuously recorded by a method[2] which largely eliminates impulsive atmospheric and industrial interference. These observations[3] frequently detected distinct noise bursts, many times stronger than the background and usually lasting a few hours.

A comparison of the radio and nightglow records shows that there is a definite correlation between the two. Of 53 nights of simultaneous observations of noise and airglow between June and December 1958, noise bursts and sub-auroræ were recorded during the same hours on 18 nights. On 27 nights neither noise nor sub-auroræ were recorded; on 6 nights noise was recorded in the absence of any auroral pattern in the airglow, while on two occasions auroræ were recorded without any noise bursts. This is summarized in Table 1.

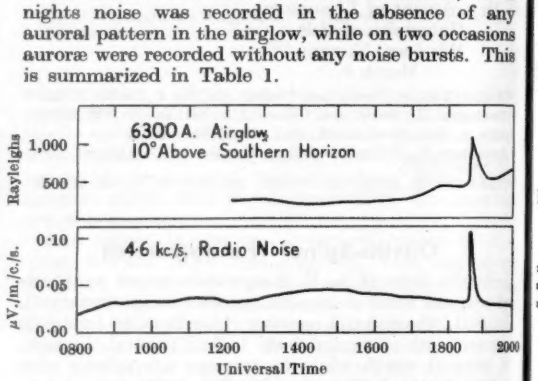

Fig. 1. Noise and auroral burst observed on July 21, 1958

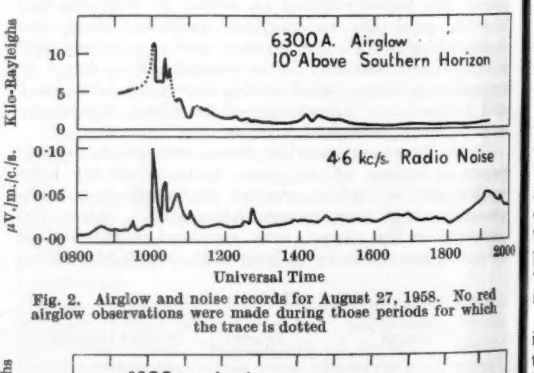

Fig. 2. Airglow and noise records for August 27, 1958. No red airglow observations were made during those periods for which the trace is dotted

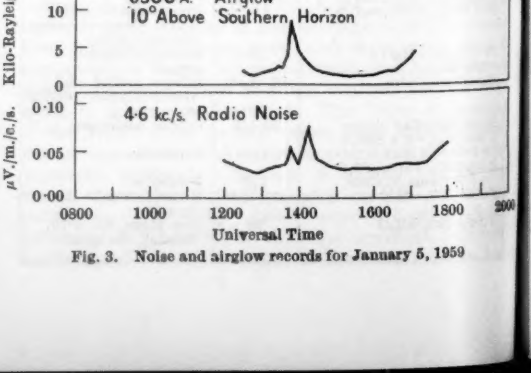

Fig. 3. Noise and airglow records for January 5, 1959

As might be expected, both phenomena are related to magnetic disturbance. They tend to occur when the disturbance index (K) reaches or exceeds 5.

On a few nights the fluctuations of noise and light intensities have shown a minute-to-minute correspondence (Figs. 1–3). This suggests that they may both be directly generated by the same phenomena, possibly the entry into the atmosphere of proton or electron streams.

However, there is in general no exact correspondence between the two; as Table 1 shows, one is occasionally observed without the other. The radio noise, unlike the auroral light, should be detectable even when its apparent source lies below the horizon. This probably accounts for much of the looseness in the association between the two, and for the occasional observations of noise without auroræ. However, the two cases of auroræ without accompanying radio noise cannot be explained in this manner. If the auroræ are caused by proton or electron streams, then it follows that such streams do not always generate radio noise.

This work forms part of the research programme of the Upper Atmosphere Section of the Commonwealth Scientific and Industrial Research Organization.

R. A. Duncan
G. R. Ellis

Upper Atmosphere Section,
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Dual Pumping Speeds of Some Ionization Pumps

In recent years the phenomenon of ion pumping in ionization gauges has received widespread attention. Work in many laboratories has shown that in an ionization gauge, activated gas molecules interact with the glass walls of the tube and are removed from the gas phase at a rate depending largely upon the pumping history of the gauge. Alpert[1], Nottingham[2] and others have shown that in the Bayard–Alpert form of gauge, the glass walls assume an electrical potential, slightly negative with respect to the cathode delivering primary electrons, and the pumping action of the gauge is due largely to ions which acquire a high kinetic energy and are driven into the walls.

Comsa and Musa[3,4] have described an ion pump in which ions are collected by the glass walls alone—there is no specific ion collector in their tube—and have calculated that the glass walls acquire a potential, determined by the equality of electron and ion bombardment, about 5 V. negative with respect to the cathode. The pumping speed of such a tube was reported to be 0·03 l./sec./m.amp.

However, experiments performed during the past three years in these laboratories on Bayard–Alpert gauges have revealed that such gauges possess two distinct pumping speeds, one about five times the other, and it has been suggested[5,6] that the electrical potential of the inner surface of the glass walls, which, it has been proposed, assumes a value approximating to either cathode or anode potential, determines at which speed the gauge shall pump. Later work on a gauge of similar design to that of Comsa and Musa has shown that this type of gauge also possesses two distinct speeds and that the wall potential can assume either of the two aforementioned values.

The potential of the inner glass surface was measured by surrounding the gauge envelope with a metal sheath which was connected via any of a number of capacitors of known value to ground. The voltage appearing upon the sheath was applied to an electrometer amplifier. The approximate voltage on the inner glass surface was then deduced from a knowledge of the capacitance of the gauge-sheath system (approx. 50 pF. as measured with a similar tube and sheath).

These measurements showed that if the glass potential approximated to that of the cathode the gauge pumped relatively quickly, but if the potential was high ($\sim$ 200 V. in our estimation) there was only a slight pumping action. In this latter condition probably few ions could reach the walls. When the gauge had been outgassed for a short time only, soon after commencing experiments, it was found possible to control the wall potential. If the electron emission was initiated before applying anode potential, the walls become stabilized at cathode potential. If, however, anode potential was applied before activating the filament, the walls became charged positively. After a number of outgassing cycles (a total of about 10 hr. at 400° C.) had been performed it was observed that no control could be exercised over the wall potential, stabilization occurring at cathode potential only.

As pointed out by Comsa and Musa, the walls become stabilized at cathode potential when the primary electron and ion currents balance, but it is believed that a second stabilization potential occurs at which the primary electron current is balanced by a current of secondary electrons emitted from the glass[7] (at about 200 V. in our experiments). When the glass is comparatively new and contains much occluded gas, the second stabilization potential can be obtained since the secondary emission coefficient of the glass can exceed unity, so allowing a current balance. When the glass is well outgassed there is evidence[8,9] to show that this coefficient will fall and stabilization at the higher potential becomes impossible. It is probable that Comsa and Musa observed one pumping action only, since they always activated the filament before applying any accelerating potentials and their outgassing techniques were stringent.

In this work a dynamic vacuum system[5,10] has been used so that the gas pressure in the experimental tube ($1{\cdot}0 \times 10^{-5}$ mm. mercury of argon) remained constant. Subsequent desorption of the pumped gas by heating the gauge enabled an evaluation of the speeds of the gauge to be made. These were: (1) when the glass became stabilized at -5 V. (approximately cathode potential), speed, 0·0003 l./sec./m.amp.; (2) when the glass became stabilized at $+$ 200 V. (approximately anode potential), speed, 0·00005 l./sec./m.amp.

The rate of ionic bombardment of the walls was determined in a gauge which included a cylindrical ion collector close to the walls, and it was shown that the higher of the above speeds corresponds to an ion clean-up efficiency of about 10 per cent.

In conclusion, it can be stated that an ion pump of the design proposed by Cosma and Musa inherently possesses two pumping speeds and in the early stages of use of this pump, especially if the pump has not

been well outgassed, either speed can be obtained by a suitable electrode potential switching sequence. The duality of pumping speeds has been found to be a result of charging of the glass walls to either approximately cathode or anode potential.

G. Carter

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April 6.

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Evidence for a Variable Long-range Order in Nearly Anhydrous Gamma Alumina

The nature of the cubic or nearly cubic alumina called γ- or η-Al_2O_3 has been the subject of much speculation. Its structural similarity to the spinels has been known for many years[1–3] and led to the view that γ-Al_2O_3 is a defect structure which can be written $Al_{21\frac{1}{3}}\ \square_{2\frac{1}{3}}\ O_{32}$ with $21\frac{1}{3}$ aluminium ions occupying statistically 24 cation sites in the spinel structure.

The recognition that γ-Al_2O_3 is frequently not a fully dehydrated alumina led de Boer and Houben[4] to suggest that 'water' may be an integral part of the structure and that an ideal formula may be $H\ Al_5O_8$ analogous to the spinels $Li\ Al_5O_8$ and $Li\ Fe_5O_8$ (see ref. 5). In these structures the lithium ions occupy particular positions in the lattice and therefore one might expect that if γ-Al_2O_3 is really $H\ Al_5O_8$, the hydrogen ions (or more likely the OH ions) likewise will occupy particular positions.

Saalfeld[6] has discussed the dehydration of gibbsite to boehmite and the subsequent formation of a nearly anhydrous alumina. The reactions are orderly in a crystallographic sense and the resulting γ-alumina is shown to be tetragonal with $a = b = 7{\cdot}95$ A. and $c = 7{\cdot}79$ A. We have found confirmation of this result in the course of studying the dehydration kinetics of a well-crystallized gibbsite. The nearly anhydrous alumina yielded a double peak in the position of the strong (400) spinel reflexion with components $d = 1{\cdot}98$ and $1{\cdot}95$ A. The longer spacing gives the more intense reflexion and corresponds to (400) and (040) with $a = b = 7{\cdot}96$ A. and the shorter spacing corresponds to (004) with $c = 7{\cdot}80$ A.

One may reasonably surmise that if dehydration occurs slowly from well-crystallized material, the ordered tetragonal structure is formed. This appears to be the γ-alumina of Stumpf[7] and Russell[8]. When dehydration takes place in a less orderly manner or from less favourable starting materials, then a statistically cubic material is formed which gives the spinel-type X-ray pattern.

We have obtained additional evidence for structural order in nearly anhydrous alumina prepared by slow dehydration of gibbsite. When the dehydration is carried beyond about 90 per cent of completion, a long spacing of the order of 30–90 A. is reproducibly

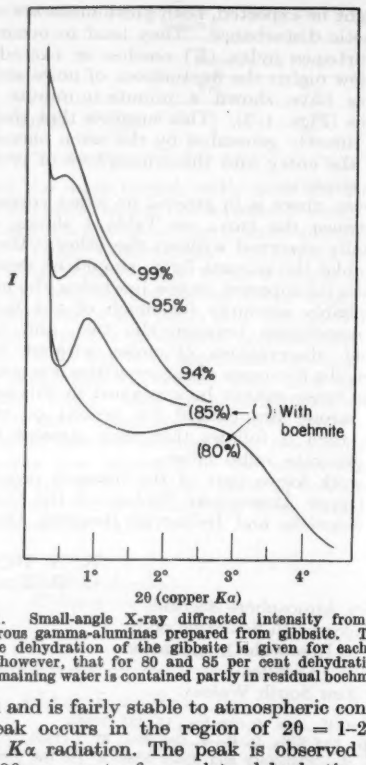

Fig. 1. Small-angle X-ray diffracted intensity from nearly anhydrous gamma-aluminas prepared from gibbsite. The percentage dehydration of the gibbsite is given for each curve. Note, however, that for 80 and 85 per cent dehydration, the remaining water is contained partly in residual boehmite

formed and is fairly stable to atmospheric conditions. The peak occurs in the region of $2\theta = 1$–$2°$, with copper $K\alpha$ radiation. The peak is observed first at about 80 per cent of complete dehydration but at this stage some boehmite still remains. Fig. 1 shows plots of diffracted intensity against 2θ and it is obvious that, as dehydration goes to completion, the diffraction peak moves to smaller 2θ values and finally is lost in the direct beam. Usually only one peak is observed, occasionally two can be observed, so that the long-range order arising from the residual 'water' is of a statistical character. The well-defined peaks shown in Fig. 1 were obtained by 12-hr. heat-treatments at successively higher temperatures up to about 500° C. Dehydration carried out directly at 450–500° C. gave poorer peaks, though they still occurred.

In terms of oxides, the ideal formula $H\ Al_5O_8$ is $Al_2O_3.\frac{1}{2}H_2O$ and corresponds to one-fifteenth of the initial 'water' content, that is, 6·7 or 93·3 per cent of complete dehydration, and the corresponding long spacing in Fig. 1 is about 65 A.

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March 2.

[1] Hägg, G., and Söderholm, G., *Z. phys. Chem.*, B, **29**, 88 (1935).
[2] Kordes, E., *Z. Krist.*, **91**, 193 (1935).
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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, June 8

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Captain M. E. B. Banks, M.B.E.: "The Ascent of Rakaposhi".

Tuesday, June 9

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 6 p.m.—Mr. S. S. Frere: "Animals in the Roman Empire".* (Last of six lectures on "Animals in Archæology".)

Tuesday, June 9—Thursday, June 11

NATIONAL PHYSICAL LABORATORY (at Teddington, Middlesex)—International Symposium on "Interferometry".

Wednesday, June 10

COMMONWEALTH FRUITS COUNCIL (joint meeting with the FOOD GROUP of the SOCIETY OF CHEMICAL INDUSTRY and the NATIONAL FARMERS' UNION, at the Royal Commonwealth Society, 18 Northumberland Avenue, London, W.C.2), at 10 a.m.—Meeting on "The Utilization of Apples and Citrus Fruits".

INSTITUTE OF INFORMATION SCIENTISTS (at the Shaftesbury Hotel, Monmouth Street, London, W.C.2), at 6 p.m.—Annual General Meeting. 7.15 p.m.—Dr. Alexander King: "The International Development of Scientific and Technical Information Services".

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in Room 425, Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Mr. L. T. Wilkins: "Some Aspects of Research Strategy in the Field of Delinquency".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. R. S. Nyholm, F.R.S.: "Colour in Inorganic Chemistry".

Thursday, June 11

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. C. M. P. Johnson, Mr. G. A. Jones, Mr. W. R. Phillips and Prof. D. H. Wilkinson, F.R.S.: "A Study of the Levels in ^{19}F Following the Beta Decay of ^{19}O"; Mr. P. Dagley, Mr. M. A. Grace, Mr. J. M. Gregory and Mr. J. S. Hill: "Nuclear Alinement of Manganese-56".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN PHYSICS—The Secretary, The University, 38 North Bailey, Durham (June 12).

CHIEF AGRICULTURAL RESEARCH OFFICER (with a first- or second-class honours degree in natural science or agricultural science, considerable research experience in tropical agriculture, and an aptitude for the direction of research) with the Government of Western Nigeria, to plan, organize and develop the work of the Research Division of the Ministry of Agriculture and Natural Resources, assist in the formulation of a crop research policy, and to advise the Agricultural Extension Services of the Region on the application of research findings to crop production problems—The Official Secretary (Recruitment Branch), Office of the Commissioner for Western Nigeria, 178/202 Great Portland Street, London, W.1 (June 13).

LECTURER IN CHEMICAL ENGINEERING—The Registrar, University College, Singleton Park, Swansea (June 15).

LECTURER (with veterinary qualifications and postgraduate research experience) IN ANIMAL HEALTH in the Biochemistry and Nutrition Section of the Department of Agricultural Chemistry—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (June 15).

RESEARCH ASSISTANT (preferably with a knowledge of vacuum techniques or infra-red detectors) IN THE DEPARTMENT OF PHYSICS for work in the Optic Group on problems connected with the construction of filters for the infra-red region above 5 microns in wavelength—The Registrar, The University, Manchester 13 (June 15).

TUTORIAL STUDENTS IN THE DEPARTMENTS OF BOTANY, CIVIL ENGINEERING, GEOLOGY, MATHEMATICS, PHYSICS and ZOOLOGY—The Registrar, King's College, Strand, London, W.C.2 (June 15).

SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (male graduate with a first- or second-class honours degree in chemistry, and preferably with some postgraduate experience) IN THE DEPARTMENT OF SPECTROCHEMISTRY, for duties covering various aspects of emission spectrochemical analysis and trace element investigations—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (June 16).

ASSISTANT LECTURER, and a TEMPORARY LECTURER (medically qualified and preferably with experience in clinical bacteriology or virology) IN THE DEPARTMENT OF BACTERIOLOGY—The Registrar, The University, Manchester (June 20).

ASSISTANT LECTURER, Grade III (preferably with special qualifications and interests in plant physiology and biochemistry) IN BOTANY—The Registrar, The University, Bristol 8 (June 20).

DEMONSTRATOR (preferably with an interest in histochemical or physiological aspects of comparative endocrinology) IN ZOOLOGY—The Registrar, The University, Nottingham (June 20).

JUNIOR RESEARCH FELLOW IN PURE MATHEMATICS—The Registrar, The University, Sheffield (June 20).

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Southampton (June 20).

LECTURER (with practical experience in the aircraft industry and preferably some research experience) IN AIRCRAFT STRUCTURES in the Department of Civil Engineering—The Registrar, The University, Leeds 2 (June 20).

LECTURER IN CHEMISTRY, and a JUNIOR LECTURER IN BIOCHEMISTRY—The Secretary, Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (June 22).

RESEARCH ASSISTANT IN THE DEPARTMENT OF BOTANY, for research on physiological genetics using tissue culture techniques—The Secretary, University College, Gower Street, London, W.C.1 (June 22).

RESEARCH ASSISTANT (with a good honours degree, a knowledge of French and German and the ability to draw maps) IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Leeds 2 (June 22).

JUNIOR FELLOW (with a university degree) IN THE DEPARTMENT OF VETERINARY SURGERY—The Registrar, The University, Bristol 8 (June 26).

ASSISTANT IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (June 27).

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Hull (June 27).

LECTURER or ASSISTANT LECTURER (with special interests in organic chemistry) IN CHEMISTRY—The Registrar, The University, Sheffield (June 27).

LECTURER (with a medical qualification) IN BACTERIOLOGY at the Royal Infirmary, Glasgow—Joint Clerk to the University Court, The University, Glasgow (June 27).

RESEARCH FELLOW IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (June 27).

CHAIR OF EDUCATION in the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 30).

DEMONSTRATOR IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Leeds 2 (June 30).

LECTURER IN THE DEPARTMENT OF CLINICAL TROPICAL MEDICINE—The Dean, London School of Hygiene and Tropical Medicine (University of London), Keppel Street, Gower Street, London, W.C.1 (June 30).

LECTURER or ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Registrar, The University, Leeds 2 (June 30).

RESEARCH WORKER (with either an ordinary B.Sc. in chemistry and some knowledge of extraction and degradation of complex organic compounds or an honours B.Sc. with emphasis on natural products) IN THE DEPARTMENTS OF ORGANIC CHEMISTRY AND BOTANY, to aid an investigation into organic constituents of soils—The Registrar, The University, Liverpool (June 30).

LECTURER IN BIOCHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 31).

SENIOR LECTURER (preferably with a sound knowledge of descriptive and/or experimental vertebrate embryology) IN ZOOLOGY—The Registrar, University of Stellenbosch, South Africa (July 31).

ASSISTANT LECTURER (with special qualifications in applied mathematics) IN MATHEMATICS—The Registrar (Room 22, O.R.B.), The University, Reading.

ASSISTANT LIBRARIAN (CHARTERED LIBRARIAN, preferably with a working knowledge of German)—The Establishments Officer, Zoological Society of London, Regent's Park, London, N.W.1.

FISHERIES OFFICER (with a university degree in biology with emphasis on zoology and experience of fisheries work) in the Northern Region of Nigeria, to execute plans for the development of river fisheries and the demonstration and organization of peasant fish culture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/408/01.

INSTRUCTOR or ASSISTANT PROFESSOR IN PROTOZOOLOGY—Dr. James R. Adams, Department of Zoology, University of British Columbia, Vancouver, B.C., Canada.

JUNIOR RESEARCH FELLOW IN MATHEMATICAL STATISTICS—The Registrar, The University, Leicester.

LECTURER (with a good background in physics or chemistry with experience of research, as supervision of student thesis work is involved) IN PLASTICS, and non-metallic materials generally, in the Department of Aircraft Materials—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

MASTER TO TEACH MATHEMATICS at all stages of the School, including the Sixth Form—The Headmaster, Boston Grammar School, Boston, Lincs.

MASTER TO TEACH PHYSICS up to at least first-year sixth standard—The Headmaster, King's College School, Wimbledon, London, S.W.19.

PROFESSOR OF PHYSICS at the University College, Colombo—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting E.9/72/TCS/CEY.

READER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, Royal Technical College, Salford 5.

RESEARCH BIOCHEMIST (Ph.D. or Ph.D. candidate), for work on pyrimidine metabolism—Dr. Arnold H. Schein, Department of Biochemistry, University of Vermont College of Medicine, Burlington, Vermont, U.S.A.

SENIOR LECTURER (with a good honours degree in zoology and preferably a special interest in either entomology or physiology) IN ZOOLOGY—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Overseas Information Services. Pp. 8. (Cmnd 685). (London: H.M. Stationery Office, 1959.) 6d. net. [43

Some Properties of Wiggin Electrical Resistance Materials. Pp. 36. (London: Henry Wiggin and Co., Ltd., 1959.) [43

The Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme. Fifth Annual Report. Pp. 8. (London: Royal Society and Nuffield Foundation, 1959.) [43

Breeding 10,000,000 Cattle. Pp. ii+31. (Thames Ditton: Milk Marketing Board, 1959.) [53

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